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The scientific publications of the National Museum include two series, known, respectively, as *Proceedings* and *Bulletin.*

The *Proceedings*, begun in 1878, is intended primarily as a medium for the publication of original papers, based on the collections of the National Museum, that set forth newly acquired facts in biology, anthropology, and geology, with descriptions of new forms and revisions of limited groups. Copies of each paper, in pamphlet form, are distributed as published to libraries and scientific organizations and to specialists and others interested in the different subjects.

The dates at which these separate papers are published are recorded in the table of contents of each of the volumes.

The present volume is the seventy-sixth of this series.

The *Bulletin*, the first of which was issued in 1875, consists of a series of separate publications comprising monographs of large zoological groups and other general systematic treatises (occasionally in several volumes), faunal works, reports of expeditions, catalogues of type specimens, special collections, and other material of similar nature. The majority of the volumes are octavo in size, but a quarto size has been adopted in a few instances in which large plates were regarded as indispensable. In the *Bulletin* series appear volumes under the heading *Contributions from the United States National Herbarium*, in octavo form, published by the National Museum since 1902, which contain papers relating to the botanical collections of the Museum.

ALEXANDER WETMORE,
Assistant Secretary, Smithsonian Institution.

WASHINGTON, D. C., August 25, 1930.

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WASHINGTON, D. C., [illegible]

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NEW FOSSIL LAND AND FRESH-WATER MOLLUSKS FROM THE REYNOSA FORMATION OF TEXAS

By William B. Marshall

Assistant Curator, Division of Mollusks, United States National Museum

A lot of fossil mollusks and fossil teeth of mammals submitted for examination by the Roxana Petroleum Corporation of St. Louis, Mo., through John C. Myers of their office at Houston, Tex., was accompanied by the following data:

> Surface samples of rock containing fossils located in south central De Witt County, Tex., along the Guadalupe River. These samples are thought to be in place, and occur in what is known as the Reynosa Formation of Tertiary Age.

De Witt County is northeast of central Texas. The Guadalupe River crosses it near its middle, and continuing its southeasterly course finally reaches San Antonio Bay on the Gulf coast. "In 1890 Penrose described a deposit of limestone containing many pebbles and cobbles under the name 'Reynosa limestone,' from the town of Reynosa, Tamaulipas, Mexico. This limestone overlies what was then called the Fayette sand at Reynosa, directly across the Rio Grande from Hidalgo, Tex. Penrose found recent shells embedded in the surface exposures of this formation, and thinking it was Recent included it in his 'post-Tertiary' formations." [1]

The name "Uvalde formation" proposed by Dumble in 1891 for another part of the same formation is no longer in use.

The fossil teeth included in the sending were submitted to Dr. J. W. Gidley, of the division of vertebrate paleontology of the United States National Museum, who says they belonged to extinct horses and rhinoceri and indicate that the deposit is probably of the Pliocene series. The fact that the mollusks are all extinct helps to confirm the belief that the formation belongs to the Pliocene.

The molluscan fossils are in poor condition, but one is sufficiently well preserved to show that it is a land shell, probably of the genus *Polygyra*. The others are bivalves, most of them internal casts. Some of them retain part of the beak sculpture, the character of which proves beyond doubt that they are pearly fresh-water mussels.

[1] A. C. Trowbridge: Professional Paper U. S. Geological Survey, No. 131-D, p. 98, 1923.

No. 2798. Proceedings U. S. National Museum, Vol. 76, Art. 1

Additional proof that they belong in this group of mollusks is found in the general form. Their abundance indicates that the Reynosa formation was of fresh-water origin. The land shell was probably fossilized after being washed into the water, or perhaps it lived on plants on the surface and dropped in and became fossilized. The fossils are composed of chalky calcium carbonate. The matrix is of the same kind of material, somewhat more compact, and in parts composed of calcite in the form of small crystals. A few small pebbles, probably of quartz, are included in the matrix.

The literature relating to the Reynosa formation is quite extensive. Two of the most recent papers are:

1923. A. C. Trowbridge: A geological reconnaissance in the Gulf Coastal Plain of Texas, near the Rio Grande (U. S. Geological Survey, Professional Paper 131–D, pp. 98–100). Regarding fossils he says (p. 100): "No fossils have been found in the Reynosa formation except the remains of land snails, crayfish, jack-rabbits, and a few other animals which have become embedded in the surface as the limestone has been dissolved and redeposited, and except the fossils originally deposited in the formations from which the gravel was derived."

1924. Alexander Deussen: Geology of the Coastal Plain of Texas west of the Brazos River (U. S. Geological Survey, Professional Paper 126, pp. 102–108). He says (p. 103): "No fossils have been found in the formation."

Footnotes to these two papers give references to many other papers relating to the subject.

Three of the mussels and the land shell retain enough of their features to warrant the descriptions given below.

PLICONAIAS, new genus

Shell subquadrate. Beaks with a number of wavy concentric undulations. Posteriorly each undulation is completed by a fine straight threadlike riblet running across the posterior dorsal area toward the beak. Anteriorly the undulations nearly fade out but are indistinctly completed by faint riblets curving toward the beak. Posterior portion of the shell with several rude plications running obliquely across the surface and of the pattern found in the plicate North American naiades such as *Amblema costata* Rafinesque; *Megalonaias gigantea* Barnes, *Plectomerus trapezoides* Lea.

Type.—Pliconaias popenoei, new species, described below.

Plicate naiades are found in the Upper Cretaceous formation of Wyoming and Utah, but do not belong to this genus.

PLICONAIAS POPENOEI, new species

Plate 1, Figures 1, 9

Shell subquadrate (posterior dorsal portion lost but evidently the form of the shell approximated that of *Amblema costata* Rafinesque).

Anterior margin regularly curved, rounding into the ventral margin, which is slightly curved but subparallel to the dorsal margin. Beak set far forward, about 10 mm. behind the extreme anterior end and 56 mm. in front of the extreme posterior end. A distinct lunule under the beak. Beak ornamented with a number of concentric, waving undulations, the main portion of each subparallel to the dorsal margin and strongest on the posterior ridge. On the posterior area a fine, nearly straight, threadlike line runs from each undulation in the direction of the beak. Anteriorly, irregular, nearly obsolete lines curve from the undulations to the beak. Posterior ridge high; anterior ridge not differentiated from the general surface of the shell. Concentric sculpture consisting of many deeply impressed lines of growth, with indications of fine concentric striae between them. Posterior half of the shell with several very prominent plications, set obliquely across the surface, parallel to the posterior ridge. In front of these are indications of several other plications which have become obsolete or which did not develop. On the posterior area of the young shell are several fine lines running from the ridge to the posterior margin. These may indicate the flutings found on the posterior area of many plicate naïades, but which can not be seen in this specimen because part of the later shell is broken away.

The type (Cat. No. 370999, U.S.N.M.) measures: Length, 66 mm.; height, 47 mm.; diameter, if both valves were present, would be about 36 mm.

As pointed out in the description of the genus *Pliconaias*, this shell is very closely related to the plicate North American naiades and may be the ancestor of some or all of them. The sculpture of the beak is such that the loss of a few undulations would convert it to the style found in *Amblema*, while an increase in their number and irregularity might produce the kind found in *Megalonaias* and *Plectomerus*.

The species is named in honor of Willis P. Popenoe, of the United States Geological Survey.

EONAIAS, new genus

Fresh-water mussels of the family Unionidae, having the beaks with numerous V-shaped loops, which are nearly regularly spaced, and which "nest" into each other, the V's pointing toward the ventral margin. Posterior area with fine riblets running from the posterior ridge to the margin. Type *Eonaias reynosenica*, new species, described below.

The nearest relative seems to be *Quadrula petrina* Gould, a pearly mussel now living in Texan waters, and which has a somewhat similar form and beak sculpture. *Eonaias* shows also some relation to

Psoronaias Crosse and Fischer, of which a couple of species are found living in northeastern Mexico, namely, *Psoronaias herrerae* Marshall and *Psoronaias semigranosus* von dem Busch, and several other species in Guatemala. In *Psoronaias* the beak ornamentation is indistinctly of the nested V pattern and the undulations are broken into numerous granules. Both genera have riblets on the posterior area running from the ridge to the margin.

The beak ornamentation is related to that of some of the Naiades of the upper Cretaceous formation of Wyoming and Utah.

EONAIAS REYNOSENICA, new species

Plate 1, Figures 3, 4, 6

Shell nearly quadrate, inflated, somewhat oblique. Dorsal margin arcuate, making nearly a right angle with the posterior margin. Ventral margin well rounded, curving abruptly, almost angularly, into the posterior margin, and slopingly rounding into the anterior margin, which is regularly curved and offsets at its upper part to allow for a large lunule under the beak. Beak set well forward, about 10 mm. back of the extreme front end and 32 mm. in front of the extreme rear end. Posterior ridge high, roundly angular. Anterior ridge not so well marked, but the anterior area making a rapid descent from the disk of the shell to the margin. Beak with V-shape undulations, "nesting" one within another, those distant from the beak tending to break into granules, especially on the anterior area. Posterior area with a number of riblets running from the posterior ridge to the margin. Concentric sculpture strong. Cavity of the shell deep, the anterior adductor scar deeply punched. Pseudocardinal teeth massive, laterals thick and short.

The type (Cat. No. 371001, U.S.N.M.) measures: Length, 42 mm.; height, 33 mm.; diameter, if both valves were present, would be about 24 mm. Other specimens (Cat. No. 371002, U.S.N.M.) have about the same proportions as the type. The largest measures: Length, 48 mm.; height, 38 mm.; diameter, if both valves were present, would be about 34 mm.

In the type some of the beak characters are almost worn away and indistinct. In some of the paratypes they are very well preserved.

ANTEDIPLODON, new genus

Characterized by elongate form, abrupt anterior end, and especially by the sculpture of the beak, which consists of several fine, clear-cut, direct, radiating riblets.

The type is *Unio dumblei* Simpson.[2] (Pl. 1, figs. 2, 8.)

[2] Simpson, Description of four new Triassic Unios from the Staked Plains of Texas. Proc. U. S. Nat. Mus., vol. 18, no. 1072, 1896, p. 383, text fig. 3.

It came from "Five miles northeast of Dockum, head of Duck Creek, Dickens County, Tex." *Unio graciliratus* Simpson,[2] p. 384, text fig. 4, and *Unio dockumensis* Simpson,[2] p. 385, text fig. 5, belong in this new genus. The fourth species described by Simpson, *Unio subplanatus* Simpson,[2] p. 383, text figs. Nos. 1 and 2, is a large fresh-water mussel but does not fall into *Antediplodon* and can hardly be an *Elliptio* (*Unio*).

At the time Simpson's paper was published the old classification of the pearly fresh-water mussels was still in use, and the importance of beak characters had not yet been fully recognized, hence his use of the generic name *Unio* for all of them. He points out the resemblance of the beak sculpture to that of some of the South American naiades. Had the new classification been in use it is probable that Simpson would have done as is being done in this paper; that is, he would have formed a new genus for the three species mentioned above as belonging to *Antediplodon*. This new genus became necessary to receive the species described below.

ANTEDIPLODON DEWITTENSIS, new species

Plate 1, Figure 7

Shell wedge-shaped, having its greatest diameter near the anterior end; tapering somewhat and having its least diameter at the posterior extremity. Beaks set far forward, about 7 mm. behind the extreme front end and about 40 mm. in front of the extreme rear end. Posterior dorsal margin nearly straight; ventral margin slightly curved, apparently joining the posterior margin in a blunt point and sharply rounding into the anterior margin. Posterior ridge lacking; anterior ridge very high, rounded. Anterior area nearly truncate, a rather large lunule near the beaks.

The type (Cat. No. 371003, U.S.N.M.) measures: Length, about 47 mm. (estimated, because a portion of the rear end is lacking); height, about 24 mm.; greatest diameter, about 24 mm.

This species is well characterized by its donaciform shape. The common east American marine shell *Donax fossor* Say if greatly enlarged would have about the same form. The species is not closely related to any other known species, recent or fossil. Its nearest relative is *Antediplodon dumblei* Simpson (*Unio dumblei*).

POLYGYRA MYERSI, new species

Plate 1, Figures 5, 10

Shell with spire depressed-conic; base full and rounded; whorls six, flattened, narrow except the last which is moderately broad. Sutures well marked; periphery somewhat angulate; sculpture of

[2] Simpson, Description of four new Triassic Unios from the Staked Plains of Texas. Proc. U. S. Nat. Mus., vol. 18, no. 1072, 1896, p. 383, text fig. 3.

numerous, rather coarse riblets of growth. Umbilicus filled but apparently wide and deep. Aperture filled, apparently rounded and extending very little below the base.

The type (Cat. No. 371005, U.S.N.M.) measures: Greater diameter, 14 mm.; lesser diameter, 12 mm.; altitude, 6½ mm.

This species may be closely related to *Polygyra texasiana* Moricand, but is larger and the material filling the aperture makes it impossible to say whether or not there were teeth. The species is named for John C. Myers, of Houston, Tex., who sent the material on which this paper is based.

EXPLANATION OF PLATE

FIG. 1. *Pliconaias popenoei* (beak sculpture), new species. × 2.
2. *Antediplodon dumblei* Simpson (beak sculpture). × 5.
3. *Eonaias reynosenica*, new species.
4. *Eonaias reynosenica* (beak sculpture of paratype). × 2.
5. *Polygyra myersi* (front view), new species. × 2.
6. *Eonaias reynosenica*, new species.
7. *Antediplodon dewittensis*, new species.
8. *Antediplodon dumblei* Simpson.
9. *Pliconaias popenoei*, new species.
10. *Polygyra myersi* (top view), new species. × 2.

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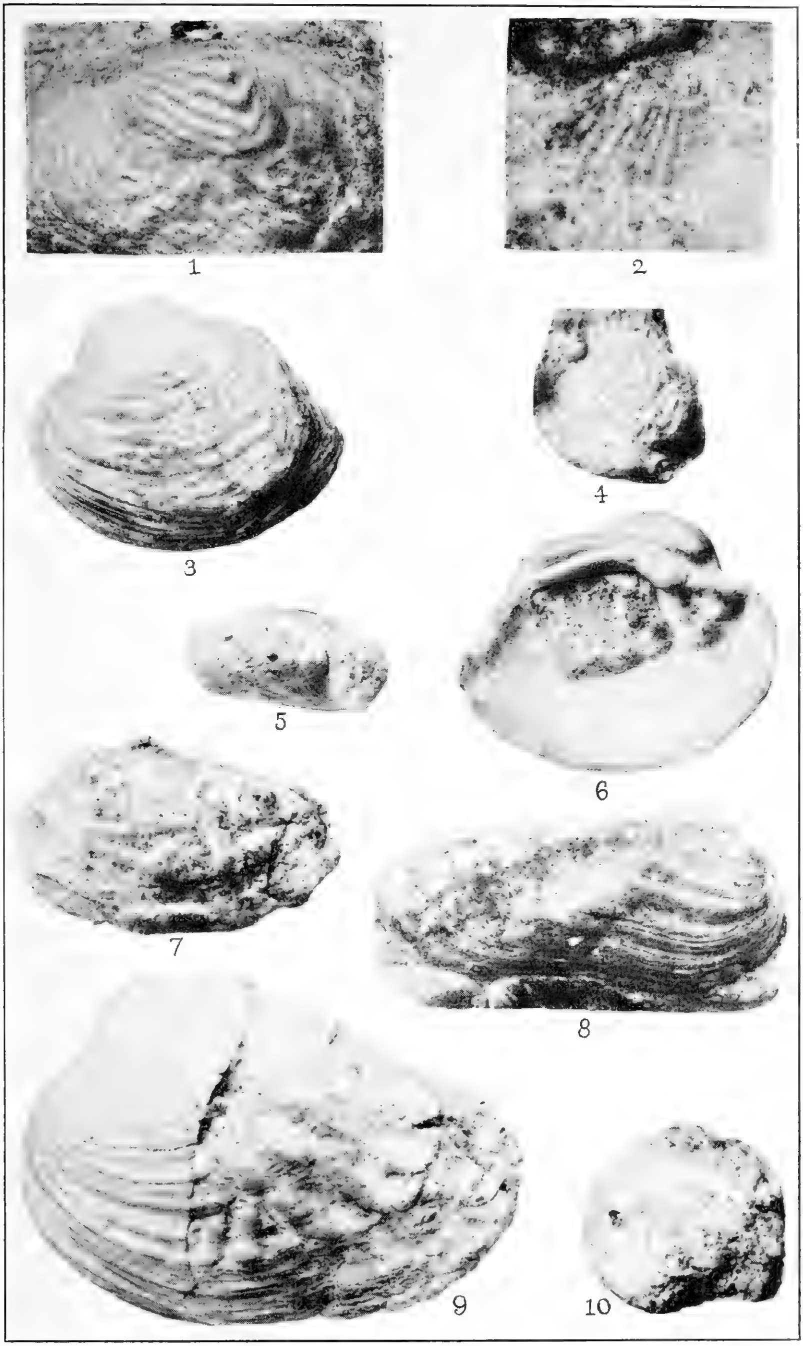

NEW MOLLUSKS FROM THE REYNOSA FORMATION OF TEXAS

FOR EXPLANATION OF PLATE SEE PAGE 6

A REVISION OF THE TWO-WINGED FLIES OF THE GENUS PROCECIDOCHARES IN NORTH AMERICA, WITH AN ALLIED NEW GENUS

By J. M. Aldrich

Associate Curator, Division of Insects, United States National Museum

Besides adding three new species and one variety to the genus, the present paper includes several rearing records, some of which have been awaiting publication for more than 40 years. It also corrects an erroneous record which has been a source of confusion for many years.

I am under obligation to Prof. H. B. Hungerford, of the University of Kansas, and Prof. R. L. Webster, of Washington State College, for the privilege of examining type material; and to Mr. Nathan Banks, of the Museum of Comparative Zoölogy, Cambridge, Mass., for careful notes on the types in that institution. Prof. A. L. Melander sent me his collection, which contained the only specimen I have seen of *Procecidochares penelope*. Dr. F. R. Cole sent his material for study, and Mr. E. P. Van Duzee sent that of the California Academy of Sciences. Dr. R. D. Glasgow sent for examination the specimens which Doctor Felt had recorded from Utah. The Vienna Natural History museum also sent for examination its only specimen of *Oedaspis multifasciata* Loew, for which I am especially indebted to custodian H. Zerny. Prof. Fr. Hendel kindly pointed out to me a series of differences between this species and our American forms.

Genus PROCECIDOCHARES Hendel

Procecidochares Hendel, Wien. Ent. Zeitschr., vol. 33, 1914, (April 30), p. 91; Abh. Ber. Königl. Zool. Anthr-Ethnog. Mus. Dresden, vol. 14, 1914 (June 15), pp. 41, 42.—Bezzi, Broteria, ser. zool., vol. 18, 1920, p. 7.—Phillips, Journ. N. Y. Ent. Soc., vol. 33, 1923, pp. 122, 136.

The type species was designated by Hendel in the first paper above as *Trypeta atra* Loew, a North American species which has until recent years been referred to *Oedaspis*, the genotype of which is *Trypeta multifasciata* Loew, a rare European species. This has the antennae far apart, the front very wide and not narrowed anteriorly, and still other differences from the group herein considered. *Cecidochares*[1] is

[1] Bezzi, Boll. Lab. Zool. Portici, vol. 5, 1910, p. 20.

a South American genus nearly related, but having the third vein setulose; its type is *rufescens* Bezzi.

The principal characters of *Procecidochares* are the following: The postorbital bristles are flattened and pale in color; the front bears only one upper orbital and two or three lower; there is a pair of dorsocentral bristles immediately behind the transverse suture of the thorax; the scutellum is swollen, globose and polished, and bears two pairs of bristles; the tergite preceding the ovipositor in the female is not shorter than the one before it; first vein setulose, third bare; wing with characteristic and quite uniform pattern consisting of a basal spot and three crossbands, of which the first and second are united in front and the third is oblique, close to costa, and does not extend much behind the fourth vein in the tip of the wing. Wings are figured by Loew, Snow, Doane, and Phillips. The common North American genus *Rhagoletis* has much the same wing pattern, but is easily distinguished by having the postorbital bristles dark and very slender, and the scutellum not swollen.

There are so many peculiar characters in *Trypeta gibba* Loew that I make it the type of a new genus *Callachna*.

KEY TO NORTH AMERICAN SPECIES OF PROCECIDOCHARES

1. Legs wholly yellow ---- 2.
   Legs with femora black ---- 5.
2. Pleurae and abdomen reddish-yellow; one presutural dorsocentral ---- **penelope** Osten Sacken.
   Pleurae and abdomen black; no presutural dorsocentral ---- 3.
3. Pleurae shining ---- **polita** Loew.
   Pleurae pollinose ---- 4.
4. Front and cheeks wide; antennae small, reaching hardly more than halfway to oral margin ---- **montana** Snow.
   Front and cheeks comparatively narrow; antennae longer, reaching nearly to oral margin ---- **flavipes**, new species.
5. With one presutural dorsocentral ---- 6.
   With no presutural dorsocentral ---- 9.
6. The posterior hyaline spot reaching middle of wing is triangular, widening rapidly to hind margin ---- 8.
   The posterior hyaline spot hardly wider at hind edge of wing than at its middle ---- 7.
7. The mesonotal patch of pale hairs is bounded on each side behind the suture by the dorsocentral bristle ---- **anthracina** Doane.
   The patch of hairs extends outside the bristle ---- **grindeliae**, new species.
8. Acrostichal pale flattened hairs in a single or slightly double row anteriorly, which widens but little to the suture; abdominal segments with distinct black hair on posterior third ---- **atra** Loew.
   Acrostichal hairs running into a large group before the suture, filling the space between the dorsocentrals; abdominal segments without noticeable black hairs ---- **atra**, var. **australis**, new.
9. Pleurae pollinose except lower part of sternopleura ---- **pleuralis**, new species.
   Pleurae shining ---- **minuta** Snow.

PROCECIDOCHARES PENELOPE Osten Sacken

Trypeta (Oedaspis) penelope OSTEN SACKEN, Western Diptera, 1877, p. 346.
Procecidochares penelope PHILLIPS, Journ. N. Y. Ent. Soc., vol. 31, 1923, p. 137, fig. 29.—JOHNSON, List Dipt. New Eng., 1925, p. 262.—WEST, List Ins. New York, 1928, p. 852.

Osten Sacken described the species from a male and female taken at Manlius, N. Y., which he attributes to J. H. Comstock. Mrs. Phillips figured the wing and partially described the species from a single specimen now in the Cornell collection, which is evidently one of the type lot, as it is labeled Manlius, N. Y., and the records of the collection show that it was collected by H. H. Smith and was in Osten Sacken's possession back in the seventies. At least one type is in the Museum of Comparative Zoölogy, and Mr. Banks gave me some notes on it. Johnson recorded the species from Chester and Westfield, Mass. West mentioned the original locality.

The only specimen I have seen is a male received for examination from Professor Melander, who collected it at Cold Springs Harbor, Long Island, in August. The species is unmistakable, all the bristles being reddish-yellow and the head, pleurae, legs, and abdomen yellow.

PROCECIDOCHARES POLITA Loew

Trypeta polita LOEW, Mon. N. A. Dipt., vol. 1, 1862, p. 77, pl. 2, fig. 12.
Trypeta (Oedaspis) polita LOEW, Mon. N. A. Dipt., vol. 3, 1873, p. 257, pl. 10, fig. 12.
Oedaspis polita JOHNSON, Cat. Ins. N. J., 1899 and 1909; Dipt. Florida, 1913, p. 83; List Dipt. New Engl., 1925, p. 262.—BRITTON, Check-list Dipt. Conn., 1920, p. 204.—PHILLIPS, Journ. N. Y. Ent. Soc., vol. 31, 1923, p. 137, fig. 28.—WEST, List Ins. New York, 1928, p. 852.

The type specimens, now in the Museum of Comparative Zoölogy, were from Mississippi and Washington, D. C.; other records in the works cited above are New Jersey, Florida, Connecticut, New York, Pennsylvania, Kansas, Georgia, Massachusetts, and Rhode Island. Unfortunately the species has been much misidentified, and I do not know from the literature which records are correct. The confusion began with Osten Sacken, who recorded the species as reared from galls on goldenrod. Mr. Banks writes me that all of the Osten Sacken reared material in the Museum of Comparative Zoölogy is *atra*, and there can be no doubt that Osten Sacken made the mistake of writing *polita* when he should have written *atra*. I have therefore transferred to *atra* all the records which appear to have been based wholly or in part on rearings. The two species are widely different, *atra* having black femora and *polita* yellow ones, etc.

Aside from the types, which I have not seen, the only specimens which I am certain belong to *polita* (although presumably many others do in the literature) are two males and two females collected by Banks at Falls Church, Va. He very kindly donated one of each sex to the

National Museum, and these are the only ones I have seen, as the species was not represented in the collection before. These have also been compared with the types by Mr. Banks.

The character used by Mrs. Phillips in the very beginning of her key to *Cecidochares*, of the lower frontal bristles being remote from the edge of the eye, does not apply to the specimens received from Banks; the whole paragraph leading to *polita* in this key applies to *gibba* more than to any other species known to me, and this I have placed in a new genus.

The Banks specimens of *polita* have yellow legs, head yellow except the upper back part; no anterior dorsocentral; the pale flattened hairs of the mesonotum leave two rounded bare polished black spots on each side, before and behind the suture; the pleurae are shining black anteriorly and below, but with a delicate pruinosity extending back from the middle of the pteropleura and covering the metanotum more densely. The middle of the mesonotum is slightly pruinose from front to back, with two rows of acrostichal pale hairs in front, separated from a single row in line with the dorsocentrals. The brown pattern of the wing is tinged with yellow except on its borders and the whole of the basal spot.

PROCECIDOCHARES MONTANA Snow

Oedaspis montana Snow, Kansas Univ. Quart., vol. 2, 1894, p. 163, pl. 6, fig. 5.

The only specimen heretofore recorded is the single male type, from Montana, which I am permitted to redescribe. The species is not represented in the National Museum. It is like *polita* and *penelope* in having the femora yellow, but separates readily by the characters of the key. It differs from both in having a smaller eye, the cheek being three-tenths of the eye height; in *polita* it is two-sevenths, and in *penelope* it is three-sixteenths. The vertex in *montana* is 0.50 of the head width, and in *penelope* 0.40; while the available specimens of *polita* being a little shrunken are not in condition to measure. The parafacials in *montana* are obviously wider than in either of the others, but difficult to measure.

Head yellow except for upper occiput. Thorax and abdomen black in ground color, the former with a distinct scar of the presutural dorsocentral on one side, the other side too much damaged to show it. Mesonotum considerably rubbed, but apparently with fewer pale flattened hairs than in most of the species; the roundish polished spots very shining, a pair before and a pair behind the suture. Scutellum badly damaged. Pleurae distinctly pollinose over their whole surface, a good mark. Abdomen also opaque, covered with white hairs, no black ones at all. Wings with yellowish pattern of three bands and a basal spot, as usual, but the apical band is short and oblique, and connects with the preceding between the second and third veins

and slightly again before the second vein; while the subhyaline area between the second and third bands widens rapidly from the third vein to the hind margin.

Length, 3.2 mm.

The specimen is in the University of Kansas collection.

PROCECIDOCHARES FLAVIPES, new species

Female.—Front at vertex 0.43 of head width, narrowing to antennae, where it is 0.34. Cheek one-seventh of eye height. These measurements indicate a much larger eye than in most of the species. Head yellow in ground color except the occipital region, wholly yellow below; palpi and antennae yellow; three pairs lower frontals; the usual pale bristles behind the eye and one black next the mouth at the side.

Thorax black, the scutellum and the two pairs of mesonotal bare spots highly polished; median region of thorax opaque and bearing the usual pale flattened hairs, it is strongly narrowed posteriorly, at the prescutellars being narrower than the space between them, then suddenly widening to border the base of the scutellum, where the flattened hairs are crowded and conspicuous. No presutural dorsocentral bristle. Anterior acrostichal pale hairs in a single row nearly to the suture. Pleurae wholly pale pollinose except a small, distinct black spot on the mesopleura in front of the wing and below the posterior notopleural bristle. Postscutellum opaque black, metanotum pale pollinose elsewhere. Halteres yellow. Abdomen black, shining on third to fifth segments, which are bare on apical half; hairs of abdomen pale. Ovipositor rather short, not equaling the three preceding segments. Wing with usual pattern which is not very dark, especially in the middle of the bands; apical band widely separated from the second, not quite touching the costa except behind the third vein; hyaline interval between first and second bands not at all widened toward hind margin of wing. Legs yellow.

Length, 3.2 mm., with ovipositor.

Described from one female, collected by H. H. Kiefer on Socorro Island, Gulf of California, May 9, 1925. Altitude, 2,000 feet. In the California Academy of Sciences.

PROCECIDOCHARES ANTHRACINA Doane

Oedaspis anthracina Doane, Journ. N. Y. Ent. Soc., vol. 7, 1899, p. 180, pl. 3, fig. 3.

Procecidochares atra (part) Phillips, Journ. N. Y. Ent. Soc., vol. 31, 1923, p. 137.

Doane described the species from two female specimens, one being from Collins, Idaho, July 27, 1928, collected by himself, the other from Battle Creek, Mich., collected by me in 1897. Mrs. Phillips placed his species as a synonym of *atra*.

The two species are before me, and I readily agree that the Battle Creek specimen is *atra*. The other, of which Doane figured the wing, and to which I restrict the species, seems to me to be distinct. I have several western specimens agreeing with the type, and I have seen no specimens of typical *atra* from farther west than the Michigan one noted as a cotype of *anthracina*. The differences are slight but seem constant in western material.

Briefly stated, the hyaline interval between the first and second wing bands is wide behind in *atra*, narrow in *anthracina*, and the mesonotum has more of the flattened white hairs in the latter. In *atra* there is a single transverse row of hairs in front of the suture, separating the anterior and posterior lateral polished mesonotal areas; while in *anthracina* there are two more or less distinct rows; the central area behind the suture, usually spoiled by the pin, has only about four rows of hairs in *atra*, about six in *anthracina*, which spread laterally in front of the scutellum in a dense or double row, where *atra* has only a thin single row. The National Museum has the following: Three females, Tennessee Pass, Colo., July 25, 1917 (Aldrich); one male, Colorado; one female, Rabbit Ear Pass, Colo., July. All the preceding agree with the type very closely.

The types are in the collection of the Washington State College, Pullman, Wash.

PROCECIDOCHARES GRINDELIAE, new species

Male and *female*.—Like *atra*, but differing in having the middle region of the mesonotum from near the front to the scutellum practically covered with appressed pale yellow hair not in distinct rows, and extending outside the dorsocentral bristle. The usual rounded polished spot on each side above the root of the wing is divided by the extension of these hairs from before more than halfway to the scutellum. While these hairs are stout enough to be conspicuous, they are not distinctly flattened. The wing pattern is like that of *anthracina*, the pale area between the first and second dark bands being narrow at the hind margin, and not widening rapidly as in *atra*.

Length, male 3 mm., female 5 mm.

Described from nine specimens of both sexes, reared at Alameda, Calif., from *Grindelia robusta*, presumably by Koebele many years ago. No record is obtainable as to the nature of the gall, but the plant is named on the label and several puparia are connected with the specimens. Another female was taken by Cockerell at Halfway House, Pike's Peak Trail, Colo., September.

Type.—Male, Cat. No. 41491, U.S.N.M. One paratype is placed in the California Academy of Sciences.

PROCECIDOCHARES ATRA Loew[2]

Trypeta atra LOEW, Centuries, pt. 2, No. 74, 1862.

Oedaspis atra LOEW, Mon. N. A. Dipt., vol. 3, 1873, p. 257. pl. 11, fig. 17.—PATTON, Canad. Ent. vol. 29, 1897, p. 247.—JOHNSON, List. Ins. N. J., 1899, p. 687.—VAN DER WULP, Biologia, Dipt., vol. 2, 1899, p. 408, pl. 11, fig. 29.—SNOW, Kans. Univ. Quart., vol. 2, 1903, p. 219.—WASHBURN, Dipt. of Minn., 1905, p. 118.—JOHNSON, List. Ins. N. J., ed. 2, 1909, p. 801.—STEBBINS, Ins. Galls Springfield, Mass., 1910, p. 52.—HENDEL, Abhandl. . . . Mus. Dresden, vol. 14, 1914, pp. 40, 42.—STURTEVANT, Journ. N. Y. Ent. Soc., vol. 26, 1918, p. 36.—BRITTON, Checklist Ins. Connecticut, 1920, p. 204.—COLE and LOVETT, List. Dipt. Oregon, 1921, p. 325.

Oedaspis polita OSTEN SACKEN, Trans. Amer. Ent. Soc., vol. 2, 1869, p. 301. Mon. N. A. Dipt., vol. 3, 1873, p. 256, footnote.—JOHNSON, List. Ins. N. J., 1899, p. 687.—BEUTENMÜLLER, Ins. Galls in Vicinity of New York, 1904, p. 33, fig.—JARVIS, Rept. Ent. Soc. Ont. for 1908 (1909), p. 81.—JOHNSON, List. Ins. N. J., ed. 2, 1909, p. 801.—GIRAULT, Ent. News, vol. 24, 1913, p. 340.—STEBBINS, Ins. Galls Springfield, Mass. 1910, p. 52.

Oedaspis setigera COQUILLETT, Journ. N. Y. Ent. Soc. vol. 7, 1899, p. 262.—WASHBURN, Suppl. List Dipt. of Minn., 1906, p. 82.—JOHNSON, List Diptera of Florida, 1913, p. 83.

Procecidochares atra PHILLIPS, Journ. N. Y. Ent. Soc., vol. 31, 1923, p. 138, fig. 31.—JOHNSON, List Dipt. New Eng., 1925, p. 262.—WEST, List Ins. N. Y. State, 1928, p. 852.

Procecidochares setigera PHILLIPS, Journ. N. Y. Ent. Soc., vol. 31, 1923, pp. 137, 138.—JOHNSON, List Dipt. New Eng., 1925, p. 262.

Male.—Shining black in ground color, including femora; the antennae, palpi, tibiae, tarsi, and most of the head yellow. Front much narrower than in *Callachna*, measuring at anterior ocellus 0.46 head width, narrowing considerably at the attachment of the antennae. Two pairs of vertical bristles, a large pair of proclinate and slightly divergent ocellars standing rather far apart, one reclinate upper orbital and two or three convergent lower ones, back of head with a row of stout pale hairs, beginning about the middle of the eye, slightly interrupted across the occiput; front with a few small pale hairs close to the eye and a few very small ones mixed with darker above the mouth and just inside the suture. Upper part of head blackish behind and on vertex, the front mostly yellow; lunule pale yellow, of good size when not abnormally retracted. Third antennal joint about twice the second, arista black, enlarged at the extreme base; palpi decidedly flattened and rather elongate. Cheek about one-fifth of eye height, dark immediately below the eye; back of head with rather short pale hair below.

[2] As mentioned under *polita*, I have assumed that references to that species which appear to be based on rearings from Solidago galls really refer to *atra*. It seems probable that misidentifications have arisen from Osten Sacken's mistake. Felt, in his Key to Galls, (p. 198), and in 34th New York Report, for 1922, (p. 76), reports *atra* reared from galls on *Chrysothamnus* at Manti, Utah, but the species was really *minuta*.

Thorax black, with a round polished area on each side between the dorsocentral bristle and the notopleura surrounded by one or two rows of white flattened hairs; another polished area on each side, behind the first mentioned, separated by the suture and a few of the same white hairs; the anterior middle part of the thorax is slightly pollinose and has two rows of acrostichal hairs which are white and slightly flattened; behind the suture this middle region is a little more pollinose and has more of the hairs. There is one very distinct dorsocentral bristle well before the suture and another slightly behind it; one farther back is regarded by Hendel as being acrostichal (presutural), although in this species it seems to be almost exactly in line with the dorsocentrals; the scutellum is globose, polished, and has two pairs of black bristles; postscutellum as in *gibba*. Halteres dark yellow with brownish knob.

Abdomen black; anterior portion of segments two, three, and four a little pollinose and bearing white hairs, the posterior portion more shining and bearing black hairs which form a rather distinct band on the second and third segments; the fourth segment is almost as long as the preceding two. On the ventral side the abdomen shows a wide space of membrane and very narrow sternites; the membrane, however, is not swollen and not visible from above.

Wings rather milky with four brown bands, the two middle ones connect anteriorly and the space between them widens rapidly to the hind border, the fourth band is entirely separated from the third and does not quite touch the costa except behind the fourth vein.

Female.—Ovipositor shining black with rather numerous black hairs, as long as the three preceding segments, tapering rather rapidly.

Length, male 3–3.4 mm., female 4.4–6 mm.

Redescribed from numerous specimens. Twenty-nine specimens were reared from galls on Solidago at Great Falls, Va., by C. T. Greene (Hopkins No. 14819*a*); the types of *setigera* include the following lots: Four specimens from Kirkwood, Mo., reared in 1884 by Miss Mary E. Murtfeldt "from leafy rosulate galls on *Solidago nemoralis*"; three specimens reared in Virginia, near Washington by Theo. Pergande from galls on Aster which deform the stem and dwarf the plant; other unreared types of *setigera* are from Bristol, R. I. (Burgess), southern Georgia (Morrison), Baldwin, Kans. (Bridwell); additional unreared specimens of *atra* are from La Fayette, Ind. (Aldrich), French Creek, W. Va. (F. E. Brooks), Cherryfield, Me. (F. H. Lathrop), Smiths Cove, Nova Scotia (C. A. Good), and several specimens collected in the neighborhood of Washington, D. C., by Shannon, Walton, Bridwell, and Kraus.

The type was in the Winthem collection and is now in the Vienna Natural History Museum; Hendel gave some notes on it in 1914.

In 1873 Loew erroneously said that the Winthem material was from Mexico; the Mexican specimen there mentioned was not included in the original publication, hence is not a type.

See *minuta* for Felt's specimens reared from *Chrysothamnus* in Utah.

PROCECIDOCHARES ATRA, variety AUSTRALIS, new variety

Differs from the typical form by the characters mentioned in the key. The second and third wing bands are slightly connected at the third vein.

Described from three specimens. The type, a female, was reared at Waco, Tex., by W. Dwight Pierce, from head of *Heterotheca subaxillaris;* it emerged October 3, 1906. One male was collected at Llano, Tex., on October 23, 1905, by A. W. Morrill; the other was taken by sweeping at Orlando, Fla., on February 28, 1918, by G. G. Ainslie (Aldrich collection).

Type.—Female, Cat. No. 41762 U.S.N.M.

PROCECIDOCHARES PLEURALIS, new species

Female.—Head yellow, the occiput black down to the neck and narrowly below; eye small and narrow, the cheek equal to almost one-third its height (0.32); front at vertex 0.51 of head width. Parafacial wider than usual, nearly as wide as third antennal joint; cheek with a few black hairs extending almost up to the eye, and behind these rather bushy pale ones. Thorax, abdomen, coxae, and basal two-thirds of femora black; middle half of mesonotum pollinose except for two narrow shining stripes in front, and with irregularly placed flattened pale hairs, which are numerous and leave only two narrow submedian bare stripes; the anterior lateral polished area is smaller than usual; scutellum polished, the postscutellum opaque above, but highly polished on lower half except laterally; metanotum white pollinose except close to junction of abdomen. Knob of halteres brown to blackish. Pleurae pollinose when viewed from in front except middle and hind part of sternopleura, when viewed from behind more shining on posterior half; no black bristles, only bristly pale hairs, on pleura. Abdomen opaque, shining only on last segment before ovipositor, the latter shining black and very long, usually longer than preceding part of abdomen without including the telescopic portion. Hairs of abdomen wholly whitish. Femora broadly yellow on apices. Wing as in Plate 18, Figure 30, of Mrs. Phillips's paper (her *setigera*).

Male.—Front at vertex 0.50 of head width; all details as in female, abdomen with only pale hairs.

Length, male 4 mm., female with ovipositor 5 mm.

Described from 16 specimens of both sexes, reared "from gall on sunflower stem," by H. K. Morrison, at Fort Huachuca, Ariz. Emerged June 9 to July 18, 1883.

Type.—Female, Cat. No. 41761, U.S.N.M.

PROCECIDOCHARES MINUTA Snow.

Oedaspis minuta Snow, Kansas Univ. Quart., vol. 2, 1894, p. 164, pl. 6, fig. 2.—Cole, Proc. Cal. Acad. Sci., vol. 12, 1923, p. 472.
Rhagoletis minuta Aldrich, Ent. News, vol. 24, 1913, p. 220.
Oedaspis atra Felt, Key to N. Amer. Ins. Galls, 1919, p. 198; 34th N. Y. Rept., 1918 (1922), p. 76.

Snow described the species from a single male in poor condition, collected in Montana. I reported a specimen under the name of a similar genus, from Olancha, Owen Valley, Calif. Cole reported the species from Puerto Ballandra, Mex., on the Gulf of California.

Snow said that the type was considerably damaged. It is before me, and apparently has not suffered since 1894. I would be at a loss to describe the species from it, but fortunately have a well-preserved specimen from Colorado correctly identified by Coquillet, which agrees with it so perfectly that it may be safely taken as the same species; other specimens cited below agree sufficiently. My description is in some details drawn from the Colorado specimen.

Head pale yellow, the black of the occiput extending to the mouth behind, but behind the lower part of the eye to the mouth the color is white and the region seems slightly inflated. Front pale yellow, the color extending back on each side of the ocellar triangle, which with the sides of the vertex is dull black; one upper and two lower orbitals; face nearly white, parafacials narrow, cheek one-seventh of eye height; antennae and palpi yellow. Thorax black, middle third slightly pruinose; no anterior dorsocentral; the flattened white acrostichal hairs in a single row at the extreme front, but increasing to several before the suture; lateral anterior shining spot very large, the posterior divided by a row of white hairs; pleura shining, the sternopleura with no black bristle (type); a white pollinose streak extending from behind the wing to the middle of the metanotum below the opaque black postscutellum. Abdomen black, subshining, with white hairs and no black ones at all. Legs yellow, the coxae and femora black. Wing as figured by Snow, the apical band connected with the second or subapical in front of the third vein (in the Colorado specimen not extending much behind the third vein at its tip). Length, 2.2 mm. (type, the Colorado specimen 2.4 mm.)

Other material which I assign to the species is as follows: Three males, two females, Manti, Utah, June 24 to July 3, reared by H. R. Hagan from ovate woolly lateral bud gall on *Chrysothamnus graveolens* (Felt's record, as *atra*); one male, one female, Colorado (Baker No. 1569); one male, three females, Claremont, Calif. (Baker); three males, Los Angeles; one female, four males, Williams, Ariz. (Barber); one male, Olancha, Calif., on *Chrysothamnus* (Aldrich); one female, Colorado Canyon, Ariz. (Barber); three males, Tucson, Ariz. (Aldrich); one female, Arizona, no collector. The females often have a blackish or quite black bristle on the sternopleura, and some

of them have three or four blackish bristles at the base of the ovipositor, not very striking. In some specimens the apical band is not connected on the third vein with the second one.

CALLACHNA, new genus

Allied to *Procecidochares*, but differs chiefly as follows: (*a*) The second vein has an erect branch on the front side near the apex, reaching the costa; (*b*) the single reclinate upper orbital bristle occurring in most Trypetidae is here replaced by a group of from three to five; (*c*) the parafacial bears a row of hairs, pale and somewhat flattened, near its anterior edge; (*d*) inside the ptilinal suture at its lower end, on what would be the base of the facial ridge if it were better developed, is a group of very noticeable stout, white hairs, which are much larger than in any species of *Prececidochares;* (*e*) the male has a singular swelling and expansion of the lateral abdominal membrane connecting the tergites and sternites.

Genotype.—*Trypeta gibba* Loew.

CALLACHNA GIBBA Loew

Trypeta (*Oedaspis*) *gibba* Loew, Mon. N. A. Dipt., vol. 3, 1873, p. 260.
Oedaspis gibba Snow, Kans. Univ. Sci. Bull., vol. 2, 1903, p. 219.
Procecidochares atra (part) Phillips, Journ. New York Ent. Soc., vol. 31, 1923, p. 137.

Loew described the female, from Texas; Snow reported the species from Douglas County, Kans.; while Mrs. Phillips thought it a synonym or a "freak" of *atra*, and did not give a definite locality. The type is in the Museum of Comparative Zoölogy at Cambridge, Mass., and was recently examined for me by Mr. Nathan Banks, who confirmed my determination.

Male.—Ground color black; legs, antennae, and palpi dark yellow; front and most of pleurae yellowish brown; eyes small and narrow; front very wide, 0.61–0.66 of head width. The stout, postorbital pale hairs from the middle of the eye upward about five in number to occipital region where they are widely interrupted, only one pair in the middle behind the ocelli. Inner and outer vertical bristles black, a small tuft of black bristles on each side of front above, considerably distant from the eye as mentioned in generic characters, only two black frontals below these. A few small white, stubby hairs irregularly placed above the lunule and at the sides close to eye. Parafacial fully as wide as third antennal joint, whitish with a dark streak extending downward from the eye; face, including lunule, rather white with a large cluster of distinct white hairs below, as mentioned in generic characters. Third antennal joint more dark brown than the basal ones; arista bare, the two basal joints distinct but short; edge of mouth rounded, not projecting; cheek about four-fifths the eye height, with a few dark hairs along the dark streak which extends

down from the eye, behind this the ground color is whitish and the hairs are conspicuous and white. Dorsum of thorax shining black with a large polished, bare space encircled by yellowish hairs in front of the suture on each side, another directly behind the suture which is divided by a fine line of yellow hairs; the middle of the thorax in front is also bare and polished; the central part of the thorax is rather densely covered with yellowish hairs and also pollinose in ground color; these hairs extend on the scutellum close to the side, leaving the large, globose, polished, central portion bare except for two pairs of black bristles and a very few yellow hairs which are perhaps absent in some specimens. All the yellow hairs of the dorsum are quite stout; the dorsocentral bristles are quite black and somewhat irregular in number, but there is always at least one before the suture; in most of the Sioux City specimens some of the hairs in the middle region before the suture are distinctly black. Pleurae yellowish brown in ground color, covered with pale pollen and with longer whitish hairs, some of which are on the pteropleura and upper edge of sternopleura; the lower and hind portion of the sternopleura is bare and shining. Halteres yellow; calypters whitish; postscutellum with an opaque blackish ridge above, immediately under the scutellum, below this covered with pale pollen except close to the junction of the abdomen.

Abdomen black in ground color, the hairs entirely white except a few at the hind edge, the second to fourth tergites are short, not reaching the sides of the abdomen which are covered with a swollen expansion of the soft membrane usually connecting the tergites and sternites. This membrane is remarkably enlarged, occupying the entire lateral portions of the abdomen and apparently replacing most of the area of the sternites below as well as invading the dorsal side of the abdomen to a considerable extent. It has several deep longitudinal grooves visible from the side, giving much the appearance of the abdomen of a female distended with eggs.

Legs dark yellow, the front femora with conspicuous pale hairs on the basal three-fifths, the apical remaining part with black hairs.

Wing with diagonal apical mark not quite filling the space to the costa in front of the tips of the second and third veins and entirely separated from the large oblique band on the middle of the wing which is broadly joined toward the costa with the subbasal band as usual. Base of the wing quite blackish a little farther than the humeral crossvein; the apical and subapical dark bands have a decided yellowish tinge between the second and fourth veins.

Female.—Abdomen entirely normal without any trace of the soft lateral membranes, the sternites and tergites occupying the usual position. Ovipositor large, its main segment almost as long as the remaining part of the abdomen, shining brown to black in color. The palpi and third antennal joint are dark brown in one specimen.

Length, male, 4 mm.; female with ovipositor, about 5 mm.

Redescribed from four males and two females reared in April, 1889, at Lafayette, Ind., by F. M. Webster, from galls on *Ambrosia artemisiaefolia;* two males and two females reared at Kirkwood, Mo., April, 1887, "from aggregated gall on *Ambrosia*" by Miss Mary E. Murtfeldt; 14 specimens of both sexes reared at Sioux City, Iowa, April, 1922, from "polythalamous gall on weed"; three males from Tallulah, La., bred in April, 1910, from a gall (Hunter No. 1944); two males from Lafayette, Ind., July 17, 1915, and August 1, 1917 (J. M. Aldrich). The larval habit of this species has not been hitherto reported, although some of this material was reared more than 40 years ago.

Nathan Banks informed me that he found two other specimens in the Johnson collection; one is from Wellington, Kans., the other from Philadelphia, Pa. Both were labeled *polita.*

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DESCRIPTIONS OF NEW SPECIES OF FORAMINIFERA OF THE GENUS DISCOCYCLINA FROM THE EOCENE OF MEXICO

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INTRODUCTION

This paper contains descriptions of those identifiable species of *Discocyclina* (*Discocyclina*) Gümbel that are available to me from Mexico. No record is made of a few specimens of whose specific identification I am not sure. The subgenus *Asterocyclina* Gümbel is also represented in the Mexican Tertiary formations, but it is not considered here. All the material described was received through the geologists of the Aguila Oil Co., except some specimens of *Discocyclina perpusilla*, which were sent me by W. S. Cole, of Cornell University, and the specimens of *D. stephensoni*, which were collected by Dr. L. W. Stephenson. The geologists with the Aguila Company from whom material was received were Messrs. Paul Weaver, D. R. Semmes, and W. S. Adkins and myself. Some of the material was submitted to me while I was resident in Washington and worked in the United States National Museum and some of it was sent to me after I transferred my home to California. An endeavor has been made to place all types in the National Museum, and this has been done except a few thin sections of specimens sent me after I came to California. Every species and the one variety are represented by type-material in the National Museum collections and topotypes are at the Scripps Institution of Oceanography.

STRATIGRAPHIC DISTRIBUTION AND SIGNIFICANCE OF SPECIES

The stratigraphic distribution of the species appears to be as follows:

Lower Eocene, Chicontepec formation.
- *D. weaveri*, new species.
  - var. *parvipapillata*, new variety.
- *D. cristensis* (Vaughan) Vaughan.
- *D. stephensoni*, new species.

Uppermost lower Eocene or lowest middle Eocene.
- *D. zaragosensis*, new species.

Middle Eocene.
- *D. cushmani*, new species.

Probably upper middle Eocene, Guayabal formation.

D. perpusilla, new species.

Probably upper Eocene, Tepetate formation (Lower California).

D. cloptoni, new species.

Eocene, horizon not reported.

D. palenquensis, new species.

Previously no lower Eocene species of *Discocyclina* have been described from America, except *D. cristensis* (Vaughan). Three species and one variety are here described. Two of these species exhibit interesting features. *D. weaveri* possesses an embryonic apparatus in which the second chamber almost entirely surrounds the first and the first two chambers are nearly surrounded by a ring of chambers larger than the succeeding equatorial chambers. *D. cristensis* was first described by me as doubtfully belonging to the genus *Orbitoclypeus* Silvestri (for references to literature, see p. 8 of this paper). The second chamber of its embryonic apparatus is reniform, but the first two chambers are surrounded by a ring of chambers that differ from the later formed equatorial chambers. It appears that *D. weaveri* and *D. cristensis* may represent an early stage in the development of *Discocyclina*. *D. cristensis* is associated with a new genus and species which I have described as *Actinosiphon semmesi* in a recent number of the Journal of Paleontology (vol. 3, p.—, 1929).

Discocyclina perpusilla is peculiar in that the annular siphon between the chambers of the same ring is situated next the distal instead of next the proximal wall of the chambers. Under the description of this species are recorded the results of experiments to impregnate the open spaces of a test with boiling balsam and subsequently to decalcify it with acetic acid, according to the method employed by Hofker. There was no evidence of any canal system. The dark lines usually seen in both the radial and annular walls of *Discocyclina* look suggestively like the canals in *Cycloclypeus*, and canals have been described by Ehrenberg and Carpenter. My experiments appeared to be against the presence of canals, but I should perhaps not be warranted in denying their presence. Should *Discocyclina* be shown to have a canal system, it would have to be removed from the Orbitoididae.

Discocyclina cloptoni is peculiar in that the two initial chambers are often doubled, trebled, or quadrupled, producing four, six, or eight, instead of only two chambers.

The other four species apparently present no noteworthy divergence from the usual generic features of *Discocyclina*.

AMERICAN SPECIES OF DISCOCYCLINA

In my paper on "American and European Tertiary Larger Foraminifera"[1] I summarized knowledge of the American species of the

[1] Geol. Soc. Amer. Bull., vol. 35, pp. 785–822, pls. 30–36, 1924.

genus up to the time of the preparation of my manuscript. The nomenclature of that paper needs to be modified by referring *Pseudophragmina* to the synonymy of *Discocyclina* and by substituting *Asterocyclina* for *Asteriacites* and placing it as a subgenus under *Discocyclina*.[2] The species described in that paper as *Orbitoclypeus? cristensis* is now referred to *Discocyclina*. One species that should have been included in my summary escaped my attention. It is *Orbitolites oregonensis* K. v. W. Palmer from beds of supposedly middle Eocene age in Oregon.[3] The species does not belong to *Orbitolites*, but to *Discocyclina* and is very close to, if not a synonym of, *D. clarki* Cushman.

Subsequent to the publication of my summary the following species have been added:

Subgenus DISCOCYCLINA Gümbel

D. mirandana H. K. HODSON, Amer. Pal. Bull., vol. 12, p. 8, pl. 1, figs. 3, 10, 13, 1926. Eocene, Venezuela.

D. perkinsi VAUGHAN, Journ. Pal., vol. 1, p. 285, pl. 46, figs. 4, 5, 1928. Upper Eocene, Jamaica.

D. citrensis VAUGHAN, Fla. Geol. Survey, 19th Ann. Rept., p. 159, pl. 2, figs. 1–5, 1928. Upper Eocene, Ocala limestone, Florida.

Dr. H. G. Schenck has in press the description of a new species from California.

Subgenus AKTINOCYCLINA Gümbel

D. (*Aktinocyclina*) *bainbridgensis* VAUGHAN, Fla. Geol. Survey 19th Ann. Rept., p. 160, pl. 1, fig. 5, 1928.

Subgenus ASTEROCYCLINA, Gümbel

Mrs. H. K. Hodson applies, in her paper cited above (1926), a number of names to specimens from Trinidad and Venezuela. She erroneously uses *Cisseis* as the generic name. It is probable that most or all of them are variants of *Asterocyclina asterisca* (Guppy). The list of names is as follows:

D. (*Asterocyclina*) *asterisca venezuelana* (H. K. Hodson)
zuliana (H. K. Hodson)
bontourana (H. K. Hodson)
pariana (H. K. Hodson)
harrisi (H. K. Hodson)
trinidadensis (H. K. Hodson)
weeksi (H. K. Hodson)
(*maracaibensis* (H. K. Hodson)
parva (H. K. Hodson)
sanfernandana (H. K. Hodson)
aurarensis (H. K. Hodson)

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[2] Vaughan, T. W., in Cushman, J. A., Foraminifera, their classification and economic use, pp. 341–345 1928.

[3] Amer. Pal. Bull., vol. 10, p. 13, pl. 2, figs. 10–14, 1923.

I have described one species as follows:

D. (*Asterocyclina*) *chipolensis* VAUGHAN, Fla. Geol. Survey 19th Ann. Rept., p. 161, pl. 1, figs. 6, 7, pl. 2, figs. 8, 9, 1928. Upper Eocene Ocala limestone, Bainbridge, Georgia.

Present knowledge of the stratigraphic distribution of the subgenera of *Discocyclina* in the Eocene in America may be tabulated as follows:

	Lower	Middle	Upper
Discocyclina	×	×	×
Aktinocyclina			×
Asterocyclina			×

The peculiarities of two of the lower Eocene, supposedly Chicontepec, species have been pointed out on a preceding page.

SYNOPSIS OF MEXICAN SPECIES OF DISCOCYCLINA

The following table may be of assistance in identifying the different species, but it does not include sufficient detail for the discrimination between the species here described and some species described in previous papers. Such detail is given in the text that follows the table.

SYNOPTIC TABLE OF MEXICAN SPECIES OF DISCOCYCLINA

Test small, less than 4 mm. in diameter.
  Shape lenticular.
    Second embryonic chamber embracing the first.
      Lateral chambers, tiers definite.
        Diameter 2 to 3 times the thickness---------- **D. weaveri.**
          4 to 5 times the thickness.
            D. weaveri var. parvipapillata.
    Second embryonic reniform.
      Lateral chambers, tiers definite.
        Diameter 4 to 7 times the thickness---------- **D. cristensis.**
      Lateral chambers, tiers indefinite.
        Diameter about 10 times the thickness---------- **D. perpusilla.**
Test 4.5 to 10 mm. in diameter.
  Test umbonate.
    Diameter about 5 mm---------- **D. cushmani.**
  Test not umbonate.
    Shape lenticular.
      Diameter 5 to 6 mm., usually 5 to 6 times the thickness.
        D. zaragosensis.
    Shape lenticular or slightly undulate.
      Diameter 6.5 to 10 mm., nearly 20 times the thickness-- **D. cloptoni.**
    Shape undulate to selliform.
      Diameter about 5 mm., about 10 time the thickness.
        Lateral chambers with definite boundaries--- **D. stephensoni.**
      Diameter about 10 mm., about 10 times the thickness.
        Lateral chambers without definite boundaries.
          D. palenquensis.

DESCRIPTION OF SPECIES

DISCOCYCLINA WEAVERI, new species

Plate 1, figures 1, 2

Test small, lenticular, papillate, especially over its central part. Diameter, 2.5 to 3 mm.; thickness, 0.9 to 1.1 mm., that is, about one-third the diameter. The center is rounded, gently domed, with sides sloping to the periphery. A large papilla over the center is about 140μ thick, and around it are about 15 radiating plates. The distance from this papilla to a surrounding circle of papillae is about 120μ. The outer papillae are smaller than those on the central dome, but they are present virtually to the edge of the test.

The embryonic apparatus consists of an initial chamber, 150μ in diameter, embraced by a second larger chamber, to the inner side of the wall of which the initial chamber is attached. The embryonic apparatus is similar to that of *Eulepidina*. The distance across the two chambers is about 200μ. The wall of the initial chamber is not well enough preserved to show the detail of its features. The wall of the second chamber is perforate and about 10μ thick. Outside the embryonic apparatus proper there is an almost complete cycle of chambers that have straight parallel sides and a slightly curved perforate outer wall. About eleven of these chambers were counted, and it is possible that they form a complete circle, but they were not recognized in an arc opposite the attachment of the initial chamber. The largest of these chambers has a radial diameter of 60μ, including the thicknesses of both bounding walls, and a transverse diameter of about 90μ. The smallest has a radial diameter of about 55μ and a transverse diameter of about 40μ. (For further detail, see description of a horizontal section of a variant, p. 6.)

The equatorial chambers are arranged in annuli, the sides are straight and parallel, and the ends are either straight or very slightly curved, but such curvature is not sufficent to prevent the formation of an annular wall. The chambers are usually only slightly elongate, almost square in horizontal section. The length, measured radially, is usually about 50μ; the transverse diameter ranges from 25μ to 40μ. The transverse diameter of some chambers exceeds the length. There is no appreciable increase in size toward the periphery. The radial walls of chambers in adjacent annuli usually alternate in position, but they are occasionally in alignment. The height of the chambers in a vertical section of a megalospheric individual ranges from about 25μ near the center to about 40μ near the periphery. The perforations of roofs and floors range from about 2μ to about 4μ across.

The lateral chambers in a vertical section have thick roofs, small cavities, and rather definite ends. There are about 10 layers, probably a few more, on one side of the equatorial layer over the center.

The height of the cavities ranges from about 8μ to 15μ; the length from about 25μ to 65μ. The roofs are finely perforate and are from about 8μ to 25μ thick. The appearance is that the roofs exceed the cavities in thickness, but some of this appearance is probably due to secondary thickening. The pillars show as thickenings of the roofs one above another.

Locality and geologic horizon.—Plaza, San Antonio, State of San Luís Potosí, Mexico. Basal part of the Chicontepec formation. The specimens were received from Paul Weaver, formerly chief geologist of the Aguila Company, for whom it is a pleasure to name the species.

Cotypes.—Two entire specimens (Cat. No. 371006, U.S.N.M.) and two thin sections, one horizontal and one vertical, deposited in the United States National Museum. Other specimens in the Scripps Institution.

There are in the collection numerous specimens that represent variants of this species. One specimen, 2.75 mm. in diameter and 1.5 mm. thick, with a strongly papillate surface, is an inflated variant. In a second variant the top of the central dome is narrower than in the typical form and there is a slight thin edge. A third variant is not so thick as the typical form and the papillae are smaller. Three specimens have the following measurements: Diameter (*a*) 2.5, (*b*) 2.5, (*c*) 3.5 mm.; thickness, (*a*) 0.75, (*b*) 0.75, (*c*) 1 mm. The papillae are from 80μ to 100μ thick. The differences from typical specimens are of degree rather than of kind.

The best horizontal section of this species is of the last-mentioned variant—that is, the slightly thinner variant with smaller papillae—and it will be described in detail. For illustration see Plate 1, figure 1.

The embryonic apparatus consists of an initial chamber entirely enveloped by a second chamber, except on one side, where the initial chamber is attached to the inside of the wall of the second chamber. The longer diameter of the initial chamber is perpendicular to the line of its attachment and measures 127μ. The diameter at right angles to the preceding is 105μ. The length of the line of attachment is about 53μ. The wall is about 7μ thick, and it is finely perforate. The diameter of the two chambers along the longer axis of the initial chamber is about 200μ; at right angles to that line it is about 220μ. The wall is about 15μ thick, except near the attachment of the interior chamber, where it is thinner. It is perforated by rather large passages, which measure as much as 5μ across. These passages precisely simulate the interannular connections, which may be seen in many places at the sides of the radial chamber walls.

The embryonic apparatus is entirely surrounded by a first annulus of the kind, not quite complete, described for a cotype of the species

(See p. 5.) It appears unnecessary to give another description of it. The chambers in it are connected with the outer embryonic chamber by the passages described, and, as seen in horizontal section, they connect with the chambers of the next annulus by passages one on each side of the proximal end of the radial walls of the chambers of that annulus. This section as cut exhibits annular connections between chambers of the same annulus in only a few places, but they are sufficient to show that an annular stolon was present.

It is unnecessary to describe the arrangement, shape, and size of the equatorial chambers, as these features do not differ significantly from those of the specimens already described. The perforations of the chamber roofs and floors are well shown in the section, and they are rather large, ranging from about 2μ to 4μ across.

A vertical section of this variant does not exhibit any noteworthy difference from the vertical section described on page 5.

The two horizontal sections of *Discocyclina weaveri* already described have the initial chamber almost entirely surrounded by the second chamber, and that relation suggested that the species might be subgenerically different from typical *Discocyclina*. A horizontal section of another of the variant just described shows an apparently reniform embryonic apparatus. This appearance may be, and probably is, due to plane of the section being inclined and not passing through the center of the chambers.

DISCOCYCLINA WEAVERI var. PARVIPAPILLATA, new variety

Plate 1, figures 3, 4, 4*a*

This variety differs from the typical form of the species by being still more compressed than the last-described variant and by having still smaller papillae, but the structural plan is the same as in the typical form and its variants. Diameter, two uncut specimens: (*a*) 2.75 mm., (*b*) 3.20 mm. Thickness: (*a*) 0.5, (*b*) 0.8 mm. Diameters of vertical sections of two specimens: (*a*) 1.4, (*b*) 1.6 mm. Thickness: (*a*) 0.44, (*b*) 0.46 mm. Of the latter two specimens (*b*) is broken on one side and was probably about 2 mm. in diameter. The diameter of the papillae ranges from 35μ to 50μ. Around each papilla are thin radiating plates, five or six in number where not broken away. These plates are more or less sinuous, coalesce, and produce a vermicular texture on the surface.

Neither of two horizontal sections showed the details of the embryonic chambers. The equatorial and lateral chambers are similar to those of the typical form except that the tests are thinner and the pillars smaller. It seems unnecessary to describe these features in detail. They are illustrated by Plate 1, figures 3, 4, 4*a*.

Locality and geologic horizon.—Plaza, San Antonio, State of San Luís Potosí, with the typical form of the species; basal part of the Chicontepec formation, probably lower Eocene.

Cotypes and paratypes.—Cotypes (Cat. No. 371007, U.S.N.M.), one entire specimen and a horizontal and a vertical section, deposited in the United States National Museum. Paratypes, similar to the cotypes, in the Scripps Institution of Oceanography.

DISCOCYCLINA CRISTENSIS (Vaughan) Vaughan

Plate 2, figures 1, 2

1924. *Orbitoclypeus ? cristensis* VAUGHAN, Geol. Soc. Amer. Bull., vol. 35, p. 814, pl. 36, fig. 8.

1928. *Discocyclina cristensis* VAUGHAN, in Cushman, Foraminifera, their Classification and Economic Use, p. 342.

The following is an edited copy of the original description of the species:

Test small, discoid. Megalospheric form, 2 mm. in diameter; thickness not known, but the test is obviously thin and waferlike. Surface of test reticulate, apparently without papillae; if present, very small.

There is a single spherical embryonic chamber, 100μ in diameter. The chamber cavity is filled with calcite which is cracked, but no dividing wall could be discerned. The chamber wall is relatively thick, about 12μ, or about one-eighth the total diameter of the chamber.

The equatorial chambers vary considerably in size and proportions. Usually the radial length exceeds the tangential width. Near the center the dimensions are about 37μ long by 25μ wide; about 0.6 mm. from the center they are about 50μ long by 31μ wide; near the periphery some chambers are squarish, 38μ long by 38μ wide. The shape is oblong or squarish. Although the chambers are approximately concentric, there is irregularity, as the illustration shows. The lateral walls of the chambers in successive cycles alternate with each other in position, and thereby produce a slight zigzagging of the boundaries between the chambers in successive cycles, but the zigzagging is so slight that the chambers are usually subrectangular in form.

Locality.—El Cristo, Vera Cruz, Mexico. El Cristo well No. 1, depth 3,775–3,785 feet. Specimen received from Mr. W. S. Adkins, of the "Aguila" Petroleum Co.

Geologic horizon.—Supposed to be Eocene, Chicontepec.

Type.—Cat. No. 371008, U.S.N.M.

The receipt of additional specimens since the publication of the original description renders possible a more complete description. Two specimens have diameters as follows: (*a*) 1.25 mm., (*b*) 2 mm. Thicknesses, (*a*) 0.17 mm., (*b*) 0.50 mm. The surface is reticulate with minute papillae, which are from 40μ to 80μ thick.

The embryonic apparatus consists of a subspherical initial chamber of about 100μ in diameter, appressed against which is a second chamber 100μ long and 50μ across. The longer diameter is parallel to the contact between the chambers. The second chamber curves on one side of the initial chamber. Between the two ends of the

second chamber there are five smaller chambers, thereby encircling the initial chamber. It appears that there is an initial spiral. The relations are indicated on Plate 2, figure 1.

A redescription of the equatorial chambers is unnecessary. To the original description it may be added that radial dark lines in the chamber wall are distinct and a similar annular line may be seen in places. The perforations of chamber cavities of the roofs and floors range between 2μ and 4μ across. The layers are about 12μ tall at the center and about 80μ at the periphery. The roofs and floors range from 18μ to 25μ thick.

One of the sections that is not quite horizontal cuts the pillars near the edge. They range from 30μ to 40μ thick, are subangular in cross section, and are subcyclical in arrangement. The distance apart slightly exceeds the thickness.

A specimen, of which a vertical section was made, measures 1.7 mm. in diameter and 0.43 mm. thick. It is illustrated by Plate 2, figure 2. There are about eight layers of lateral chambers over the center; they decrease in number toward the edge, where there is one layer over the equatorial chambers, which project only slightly or not at all beyond the lateral chambers. The lateral chambers are rather definitely outlined, but are variable in size. The height of the cavities ranges between about 8μ and 15μ, with roofs, which are perforate, of approximately the same thickness. Maximum length about 80μ, about half that length more frequent, and some chambers as seen in the section are shorter. The pillars are produced by serial thickenings, one above another, of the chamber walls.

All the specimens described are from the Aguila El Cristo well No. 1, depth 3,775–3,790 feet. The original type is in United States National Museum. One horizontal section here described is also deposited there. The vertical section belongs to the Scripps Institution of Oceanography.

DISCOCYCLINA PERPUSILLA, new species

Plate 2, figures 3, 4, 5, 5*a*

1928. *Discocyclina clarki* COLE, Amer. Pal. Bull., vol. 14, p. 36, pl. 2, fig. 31 (not *Orthophragmina clarki* Cushman).

Test small, very thin, waferlike. The diameter ranges from 0.6 to 2.3 mm., as is shown by the five specimens illustrated by Plate 2, figure 3. The thickness through the center of a specimen about 2 mm. in diameter is about 180μ; that is, the diameter is about ten times the thickness. Very minute papillae on the surface.

The embryonic apparatus is reniform. The initial subspherical chamber is about 50μ in diameter; the diameter of both chambers measured through the center of the initial chamber is about 95μ.

The first eight annuli are rather narrow, 30μ to 40μ wide, beyond which the width is between 80μ and 100μ. The chambers are rectangular; the radial diameter the same as the width of the annuli; tangential diameters between 40μ and 65μ. The earlier chambers are square; the later ones are elongate. The radial walls of chambers in adjacent annuli may or may not be in alignment. The height of the chamber cavities at the center is about 10μ; at the periphery, 1 mm.; from the center, about 35μ. The roofs and floors are rather thin, ranging from 4μ to 12μ thick, and are finely perforate; the perforations are about 1μ across. Chambers in the same annulus communicate by stolons at the *distal ends* of the chambers, *not* at the *proximal* ends as in *Discocyclina pratti;* chambers of adjacent annuli connected by stolons that pass through the annular walls.

Lateral chambers well developed, four or five layers over the center. There is a free edge equal to the width of one annulus, about 120μ in the specimen here described. Height of cavities variable, range from a barely detectable slit to 15μ. Length also variable, range from 8μ to 80μ. Roofs range from 7μ to 15μ thick, about the same as the height of the chamber cavities. There are no definite vertical tiers of lateral chambers. Small pillars present, as much as 25μ in diameter at the surface; some appear to have their origin at the equatorial layer.

Localities and geologic horizon.—All localities in State of Vera Cruz. Soledad Crossing over Rio La Puerta, Cantón Tuxpan, collected by T. W. Vaughan (M. 84 V.); Rio Tuxpan, mouth of Rio Pantepec, collected by Paul Weaver (M. 65 V.); Zardo Creek, Cantón Tantoyuca, 0.7 km. southwest of Tierra Colorada, collected by T. W. Vaughan (M. 115 V.); Guayabal, collected by W. S. Cole. Guayabal formation, upper middle Eocene.

Cotypes.—Cat. No. 352881, U.S.N.M.

Since the specimens belonging to this species are extraordinarily well preserved, an endeavor was made to make an especially thorough study of its minute structure. Accordingly a section was impregnated with balsam and decalcified according to the method described by Hofker,[4] and it was compared with a similarly prepared section of *Heterostegina suborbicularis* d'Orbigny from Tonga Islands. The preparation of the last species shows the canal system filled with balsam while the calcareous test had been removed. Therefore, it served as an excellent basis for the study of the preparation of *Discocyclina perpusilla.*

The stoloniferous passages between the equatorial chambers of the same annulus, the passages between successive annuli, and the perforations of chamber roofs and floors were perfectly shown in *D. perpusilla*, but there was no trace of any canals in either the annular

[4] Hofker, The foraminifera of the *Siboga* Expedition, Pt. 1, 1927, p. 2.

walls or the radial chamber walls. The walls entirely dissolved and left open spaces devoid of canals.

Two partially decalcified preparations were made of *D. pratti* from Côtes Basques, Biarritz, *Pentacrinus marl*, collected by M. N. Bramlette, and several thin sections that were not decalcified were made. The passages for stolons were obvious, but no trace of canals could be found. There is usually a dark median line in each radial chamber wall, and often minute dark granules are present along it, but apparently it does not represent a canal. A similar line can also be seen in places within the annular wall, but no annular canal, such as the marginal canals of *Heterostegina*, were recognized.

This discussion may be summarized and terminated by the statement that no definite trace of a canal system was found in *Discocyclina*.

DISCOCYCLINA CUSHMANI, new species

Plate 3, figures 1–4

Test circular in plan, thin except in the center, where there is a distinct, sharply demarked circumvallate, dome-shaped umbo. Diameter of the test, 5 mm.; diameter of the umbo, 1.3 mm., about one-quarter the diameter of the test. Thickness of test through the umbo as much as 1.8 mm.; outside the umbonate area, thickness, 0.56 mm.; that is, the thickness through the umbo is about three times that of the surrounding part of the test. Outer surface densely and coarsely granulate. Over the umbo and in the area adjacent to it the granulations range from 30μ to 60μ across; they are subcircular or elliptical in plan and do not exhibit definite arrangement. Exterior to the area above described the granulations have a rather definite cyclical arrangement occurring above the annular chamber walls. Although some of the granulations are decidedly small, their size in general is about the same as those more centrally situated. The cross section of many of them is subrectangular.

Embryonic apparatus reniform. Initial chamber subspherical, about 100μ in diameter; distance across both chambers through the center of the initial chamber about 200μ. Wall about 10μ thick. The embryonic chambers are typical for the genus.

Equatorial chambers rectangular, in definite annuli. The width of the annuli increases toward the periphery; it is from 24μ to 40μ near the center and as much as 200μ at the periphery. The chambers near the center are almost square, but become elongate rectangles toward the periphery, where the transverse diameter is between 40μ and 50μ and the radial diameter as much as 200μ; that is, the radial is four or five times the transverse diameter. The equatorial layer at the center of the test is so thin that it almost pinches out; the height of the chambers may be less than 8μ; at the periphery the height is as much as 24μ. The roofs and floors are

relatively thick, as much as 60μ, and are pierced by numerous, minute, cribriform perforations, which are about 2μ in diameter, some slightly smaller, others slightly larger.

Lateral chambers well developed and distinctly demarked. The number of layers in the thick umbonate area is as many as 20 on each side of the equatorial layer. Outside the umbonate area the number decreases to eight or less, and at the actual periphery there are about two. The equatorial layer does not appreciably protrude at the periphery. The ends of the chambers are formed by definite pillars, of which at least many have their inner ends at the equatorial layers. Most of the pillars do not show definite increase in thickness toward the periphery, but some do. The thickness is not uniform, but ranges from 16μ to about 60μ, with 80μ as an apparent maximum. The length of the chamber cavities ranges from about 40μ to 160μ, and the height ranges from 8μ to 32μ; 24μ is common. The roofs range from 8μ to 16μ thick and are pierced by cribriform perforations similar to those of the roofs and floors of the equatorial chambers. Longitudinal perforations, tubular cavities, appear also to be present in the pillars. The chambers form rather definite tiers, the pillars being at the sides of the tiers. In places the ends of the chamber roofs on opposite sides of the pillars alternate with each other in position. The pillars emerge on the surface to form the granulations already described.

Localities and geologic occurrence.—This is the commonest species of *Discocyclina* in the Mecapala Hills southwest of Tantoyuca, State of Vera Cruz, Mexico, and it is abundant at many places in that general area. Its association with *Ostrea sellaeformis* Conrad and its stratigraphic relations are the basis of the opinion that the horizon is that of the Lisbon formation of the Claiborne group in Alabama—that is, middle Eocene—but it may also occur in beds of upper Eocene age. The field evidence is not decisive.

Cotypes.—Cat. No. 371009, U.S.N.M. The actual description of the species is based on a single excellent specimen (pl. 3, fig. 1) from locality M.108 V., Zardo Creek, 0.7 km. southwest of Tierra Colorada, Cantón Tantoyuca (collected by T. W. Vaughan), and specimens in the matrix and three thin sections of rock from Buena Vista Creek, Mecapala Hills, Las Piedras coordinates, 1,050 m. north and 2,610 m. east (collected by G. E. Ebmeyer and H. L. Rau). Two thin sections are illustrated by Plate 3, figures 3, 4. The cotypes are deposited in the United States National Museum. Plate 3, figure 2, illustrates a split specimen, a paratype, from locality M. 104 V., 8 km. northwest of Tantoyuca on the road to Dos Caminos (collected by T. W. Vaughan).

Discocyclina cushmani is a flat, distinctly umbonate, densely granulate species, which has well-developed pillars and well-defined

lateral chambers that occur in rather definite tiers. Its diameter is about 5 mm. It is obviously necessary to compare it only with flat umbonate species. Those described from America are *D. marginata* (Cushman), which is much larger, 12 to 14 mm. in diameter; *D. clarki* (Cushman), which has a smaller umbo and smaller, more scattered surface papillae; and *D. flintensis* (Cushman), which needs detailed consideration. *D. flintensis* is very close to *D. cushmani*. It differs principally by having a smaller and less prominent umbo; the test is thinner, more nearly flat; and the surface granulations are not quite so prominent.

Another form that deserves mention in this connection is one that is abundant in the Ocala limestone on the east side of Flint River, about 1½ miles north of Bainbridge, Ga. The specimens are sublenticular or umbonate, between 3.5 and 5 mm. in diameter, and the surface is coarsely granulate. The thickness through the center ranges from 1 to 1.5 mm. The umbos of the umbonate individuals are less sharply demarked and are somewhat larger and the sculpture is coarser than in *D. cushmani*. The sculpture is similar to that of *D. floridana* (Cushman),[5] and the specimens should perhaps be considered a variant of that species. However, they appear to be persistently of smaller diameter than *D. floridana*, and they also differ by being sublenticular or umbonate. The specimens, although similar in some features to *D. cushmani*, are different and represent either a variant of *D. floridana* or a new species.

This species is named in honor of Dr. Joseph A. Cushman, who has done much to increase knowledge of foraminifera.

DISCOCYCLINA ZARAGOSENSIS, new species

Plate 4, figures 1, 2, 3

Test lenticular, 5 to 6 mm. in diameter, thickness through the center 0.5 to 1 mm., slope from the center to the margins gradual, producing a slightly domed but not an umbonate center. Surface of test from the central part to near the periphery papillate; papillae with rounded ends, 100μ to 170μ in diameter, rather crowded, and tend toward arrangement in short, rather wavy rows.

Embryonic apparatus composed of a smaller partly embraced by a larger chamber, as is usual in *Discocyclina*.

Equatorial chambers rectangular, small. Length radially from 30μ to 50μ or less; tangential side about 23μ long; height about 23μ, with very slight increase in height toward the periphery. In places the equatorial layer very nearly pinches out.

Lateral chambers well developed, but not sharply defined, about 10 or 11 on each side of the center of a specimen 1 mm. thick.

[5] U. S. Geol. Survey Prof. Pap. 125, pl. 9, fig. 7, 1920.

Toward the equatorial layer the chamber roofs are so thickened as almost to obliterate the chamber cavities; near the surface the roofs are thinner, 23μ to 30μ thick, and the cavities are more open, but they are not of uniform thickness. The chamber lengths are also very variable, ranging from 40μ or less to as much as 250μ. Pillars are well developed. Some have their origin at the equatorial layer and extend as narrow cones to the outer surface, where they form papillae as much as 160μ thick.

Locality and geologic horizon.—About 2 miles south of Zaragosa, State of Nuevo León, Mexico (collected by T. W. Vaughan, November 7, 1920), in association with *Venericardia potapacoensis* Clark and Martin. The horizon is very low in the Claiborne group or high in the Wilcox group; that is, very low middle or very high lower Eocene.

Cotypes.—Cat. No. 371010, U.S.N.M.

Discocyclina zaragosensis differs so much from any other hitherto described American species that it scarcely needs to be compared with any of them. The most nearly related species is probably *D. perkinsi* Vaughan from the upper Eocene of Jamaica, but that species is larger, not so distinctly domed in the center, and its papillae are finer.

DISCOCYCLINA CLOPTONI, new species

Plate 5, figures 1–6

1925. *Orthophragmina* species VAUGHAN, Second Pan-Pacific Sci. Cong. (Australia) Proc., vol. 1, p. 870.

Test very thin, lenticular, nearly flat or slightly undulate. Diameter ranges from 6.5 to 10 mm.; outer faces almost parallel; thickness through the center of a specimen about 8 mm. in diameter about 425μ, (pl. 5, fig. 6). Surface beset with very minute papillae, 50μ, or even less, thick.

Embryonic apparatus composed of two, four, six, or eight chambers. In specimens in which it is composed of two chambers, it is typically reniform, 350μ across the chambers between the horns of the outer chamber and 300μ perpendicular to that line through the center of the initial chamber. The walls are rather thick, about 30μ. There may be two, three, or four such pairs of chambers, as is shown in the illustration (pl. 5, figs. 2, 3, 4, 5).

Equatorial chambers rectangular, arranged in definite annuli, which increase in width toward the periphery of the test. About 2 mm. from the center of the specimen illustrated by plate 5, figure 2, the width of an annulus is from about 40μ to 60μ. In another specimen the width near the center is about 24μ, but at the periphery it is as much as 100μ; about 80μ is frequent. The radial walls are not well

preserved. It appears that the more usual condition is for walls of chambers in adjacent annuli to be in alignment, but that this condition is not invariable. The length of the chambers usually exceeds the width. The equatorial layer is very thin, only about 15μ tall near the center and about twice as tall near the periphery.

The lateral chambers are very low, the cavities being small. There are seven or eight, possibly nine, layers over the center, the number decreasing to about two at the periphery. The thickness of the walls separating the layers exceeds the height of the chambers, which is about 7μ, while the walls range from about 14μ to 21μ thick. The length of the chambers is variable, but it is several times the height. The chamber ends are not clearly marked, but are formed by successive overlapping of walls. There are no clearly developed pillars, but there are on the outer surfaces of the chamber walls small papilliform elevations.

Localities and geologic horizon.—Arroyo Guadalupe, 50 miles northwest of La Paz, Lower California, collected by J. H. Clopton, for whom the species is named. Tepetate formation, middle or upper Eocene.

Dr. W. S. W. Kew, in connection with investigations he conducted for the Marland Oil Co., collected specimens in the Eocene Tepetate formation and presented them to the United States National Museum. The following is a list of the U. S. G. S. locality numbers and the localities: 9687, Arroyo Lievre, about 5 km. east of Rancho Saucito; 9696, Arroyo Colorado; 9697, 1 mile northeast of Rancho Colorado, in Arroyo Colorado (upper part of Tepetate formation); 9698, Arroyo Colorado, at ranchito northwest of Cerro Colorado (near top of Tepetate formation); 9706, Arroyo Colorado, above Rancho Colorado (upper beds of Tepetate formation).

This species seems to be the one previously referred to "*Orthopragmina*" *pratti* (Michelin) by Prof. H. Douvillé, basing his determination on specimens collected by Dr. A. Heim[6] in Lower California along Arroyo Colorado in the Tepetate formation. A large suite of *Discocyclina pratti* is in the collections of the Scripps Institution, and *D. cloptoni* is decidedly different. *D. cloptoni* is not umbonate and its embryonic apparatus is peculiar, as well as differing in other respects.

Types.—Cotypes (Cat. No. 371011, U.S.N.M.), the figured specimens collected by Mr. Clopton on Arroyo Guadalupe. Topotypes, in the Scripps Institution of Oceanography.

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[6] Douvillé H., Les orbitoïdes de la presqu'île de Californie, Acad. Sci. Compt. Rend., vol. 161, p. 109, 1915; Heim, A., Sur la géologie de la partie méridionale de la basse Californie, Compt. Rend., vol. 161, p. 119; Heim, A., Notes on the Tertiary of Southern Lower California, Geol. Mag., vol. 59, p. 529, 1922 (see especially pp. 534–5).

DISCOCYCLINA STEPHENSONI, new species

Plate 6, figures 1–4

Test flat, subdiscoid, more or less undulate, even crumpled; very thin, only slightly increasing in thickness toward the center, without any umbo. The diameter somewhat exceeds 4.5 mm., probably about 5 mm. or a little more. Thickness through the center about 0.5 mm. Surface beset with very minute papillae, which measure as much as 40μ thick.

Embryonic apparatus reniform, initial chamber spherical, about 140μ in diameter; distance across both chambers, 240μ.

Equatorial chambers rectangular, in definite annuli, which are of about the same width, about 50μ near the center and near the periphery. The length of the chambers along radial lines usually exceeds the width, but some chambers are nearly square. The radial chamber walls of adjacent annuli may or may not be in alignment; the latter condition appears to be the more common. The equatorial zone is very thin, the actual height of the chamber cavities ranging from 25μ to about 40μ. The roofs and floors are about 25μ thick. The entire thickness of the layer, including roofs, floors, and chamber cavities, ranges from about 75μ to 90μ. The minute perforations leading from the equatorial to the lateral chambers are excellently shown; they are small and tubular, about 1μ in diameter.

The lateral chambers are very well defined; over the center of the test they form five or six layers and near the periphery about three. In places there are rather well-marked tiers. The height of the chamber cavities ranges from about 12μ to 24μ; the length from about 40μ to 100μ, the length usually measuring several times the height. The roofs range in thickness from about 16μ to 32μ. There are in the roofs fine perforations leading from one chamber to the next outer similar to the perforations above noted for the roofs and floors of the equatorial chambers. Although the chamber ends are very well marked, pillars are only slightly developed and produce small, low papillae on the surface.

Localities and geologic horizon.—From loose boulders, No. 194, canyon, about 2 miles southwest of San Pedro, and No. 196, Guerrero road, about 3 kilometers east of Tanlajas, State of San Luís Potosí, Mexico, collected by L. W. Stephenson, for whom the species is named. Probably the Chicontepec formation, lower Eocene.

Cotypes.—Cat. No. 371012, U.S.N.M. Four thin sections of a specimen from locality 194.

The most nearly related species is *D. palenquensis* Vaughan, described in this paper. That species is somewhat thicker and its lateral chambers are more numerous and not so well defined. The illustrations show the differences in the vertical sections.

DISCOCYCLINA PALENQUENSIS, new species

Plate 4, figure 4; Plate 7, figures 1, 2

Test thin, undulate or more or less selliform. Diameter as much as 10 mm.; thickness through the center as much as 1 mm.; at the periphery about 0.25 mm.; increase in thickness toward the center very gradual, without the production of a central umbo. Surface nearly smooth, with small papillae, which range from 23μ to 38μ in diameter.

The embryonic chambers were not observed.

Equatorial chambers rectangular in horizontal section, in definite annuli; usual radial distances between the annuli are between 30μ and 45μ; transverse width of the chambers 23μ to 38μ. Many chambers are virtually square. The radial walls of chambers in adjacent annuli appear to be more frequently in alignment, but this not invariably the arrangement. A dark line is persistently present in the annular walls, and a similar line is usually seen in the radial chamber walls. The equatorial layer is very thin, variable in thickness, about 7μ at the center, but between 30μ and 60μ toward the periphery.

The lateral chambers are very narrow, separated by walls which are usually much thicker than the intervening chamber. The boundaries of the chambers are not definite, and attempts to determine the number of layers do not yield precise results. The number over the center is between 15 and 22. The chamber ends also are not clearly marked; the length, however, generally exceeds the height. Small pillars with pointed inner ends are present. The size of corresponding surface papillae has already been stated.

Cotypes.—Cat. No. 371013, U.S.N.M.

Locality and geologic horizon.—Eight and a half kilometers south of Trinidad, Cantón of Palenque, State of Chiapas, Mexico, collected by J. B. Burnett. Eocene; information as to the precise horizon not available; probably middle or upper Eocene.

Notes on the differences between *D. palenquensis* and *D. stephensoni* are given after the description of the latter species.

EXPLANATION OF PLATES

PLATE 1

FIGS. 1, 2. *Discocyclina weaveri,* new species. Fig. 1, embryonic and equatorial chambers, × 80, paratype; fig. 2, vertical section, × 40, cotype. See p. 5.

3, 4, 4*a*. *Discocyclina weaveri* var. *parvipapillata,* new variety. Cotypes. Fig. 3, section obliquely through the equatorial plane, × 40; fig. 4, vertical section, × 40; fig. 4*a*, part of vertical section, × 80. See p. 7.

PLATE 2

FIGS. 1, 2. *Discocyclina cristensis* (Vaughan) Vaughan. Plesiotypes. Fig. 1, embryonic and equatorial chambers, × 80; fig. 2, vertical section, × 40. See p. 8.

3, 4, 5, 5*a*. *Discocyclina perpusilla,* new species. Fig. 3, general views of five specimens, × 10, cotypes; fig. 4, embryonic and equatorial chambers, × 40, paratype; fig. 5, vertical section, × 40, paratype; fig. 5*a*, part of vertical section, × 80, passage for stolon shown just inside the vertical wall at the extreme left. See p. 9.

PLATE 3

Discocyclina cushmani, new species

FIG. 1, surface, × 15, cotype; fig. 2, part of equatorial plane of a split specimen, × 15, paratype; fig. 3 vertical section of umbo of a specimen, × 40, cotype; fig. 4, oblique section, some pillars cut longitudinally, others obliquely; cotype. See p. 11.

PLATE 4

FIGS. 1, 2, 3. *Discocyclina zaragosensis,* new species. Cotypes. Fig. 1, surface, × 10; fig. 2, equatorial plane of a split specimen, × 10; fig. 3, vertical section, × 20. See p. 13.

4. *Discocyclina palenquensis,* new species, piece of rock in which there are many specimens; cotypes (see also pl. 7). See p. 17.

PLATE 5

Discocyclina cloptoni, new species. Cotypes

FIG. 1, surfaces of two specimens, × 5; fig. 2, embryonic and equatorial chambers, × 20; fig. 3, single embryonic chambers, × 20; fig. 4, double embryonic chambers, × 20; fig. 5, quadruple embryonic chambers, × 20; fig. 6, vertical section, × 20. See p. 14.

PLATE 6

Discocyclina stephensoni, new species. Cotypes

FIG. 1, part of equatorial plane, surface reticulum, and pillars, × 20; figs. 2, 3; 4, vertical sections, × 20, to show variation in form. See p. 16.

PLATE 7

Discocyclina palenquensis, new species. Cotypes

FIG. 1, parts of the equatorial plane and surface of a specimen, × 20; fig. 2, vertical section, × 20. (See also pl. 4, fig. 4.) See p. 17.

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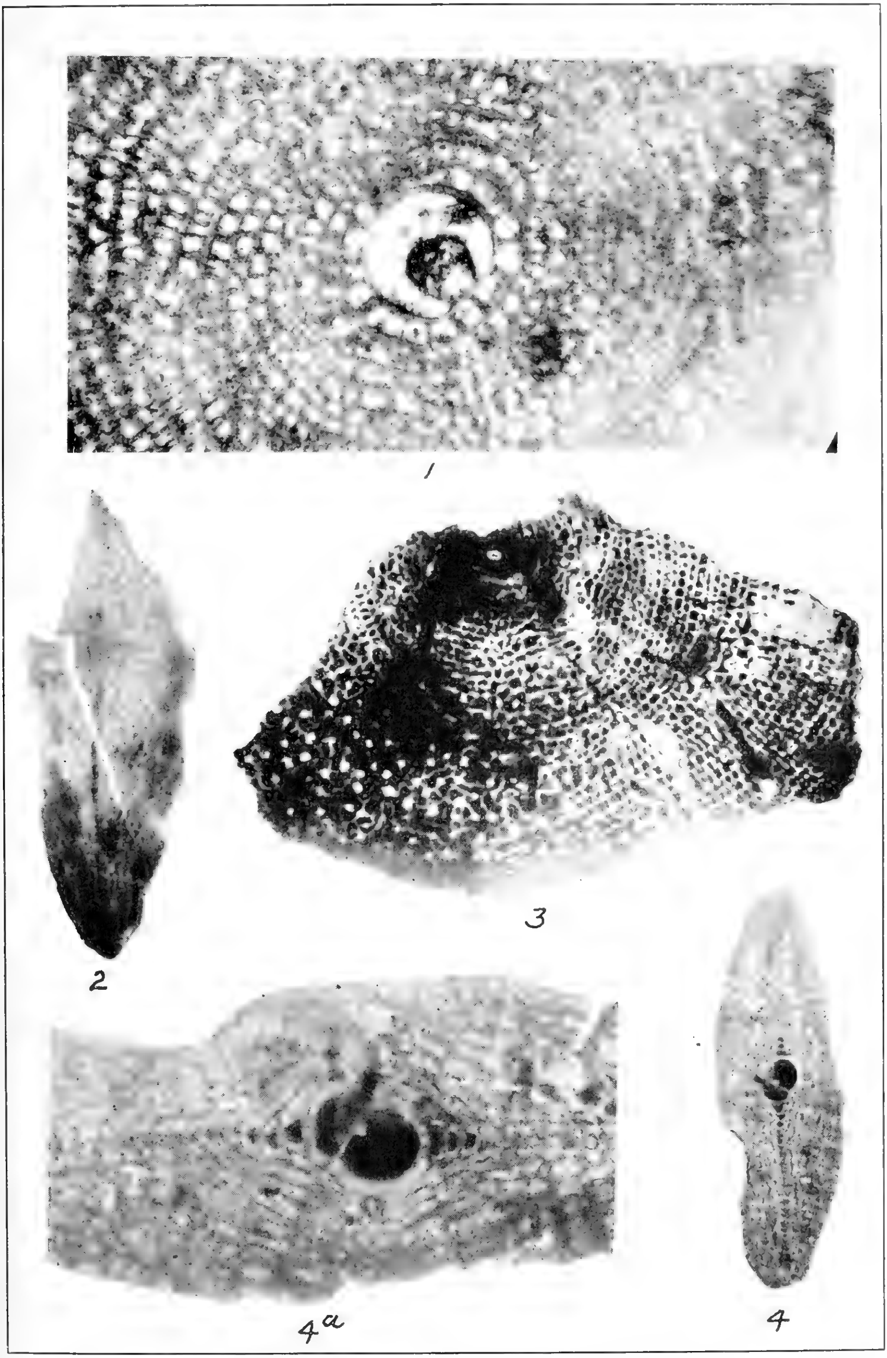
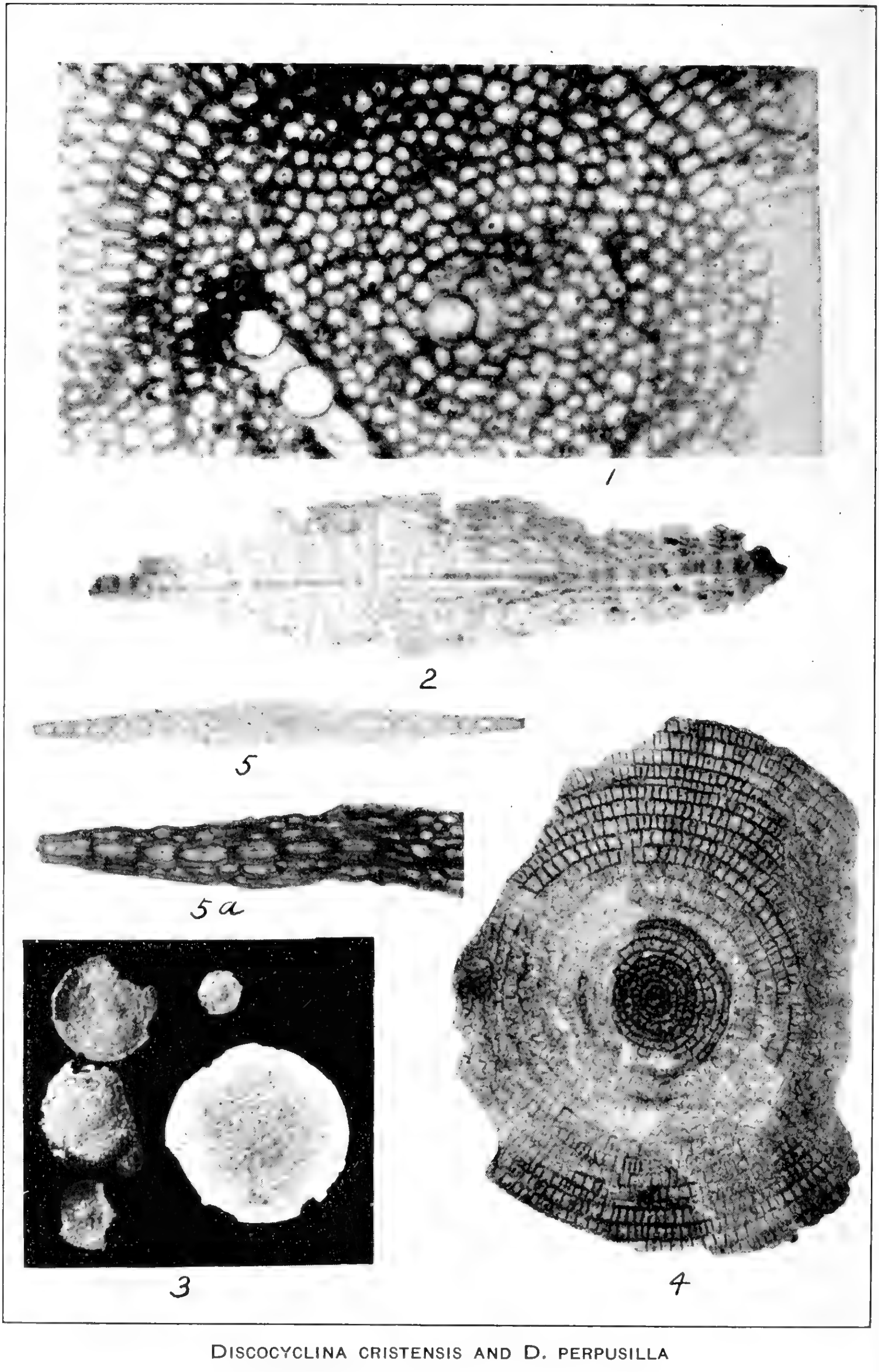


DISCOCYCLINA WEAVERI AND D. WEAVERI VAR. PARVIPAPILLATA

FOR EXPLANATION OF PLATE SEE PAGE 18



DISCOCYCLINA CRISTENSIS AND D. PERPUSILLA

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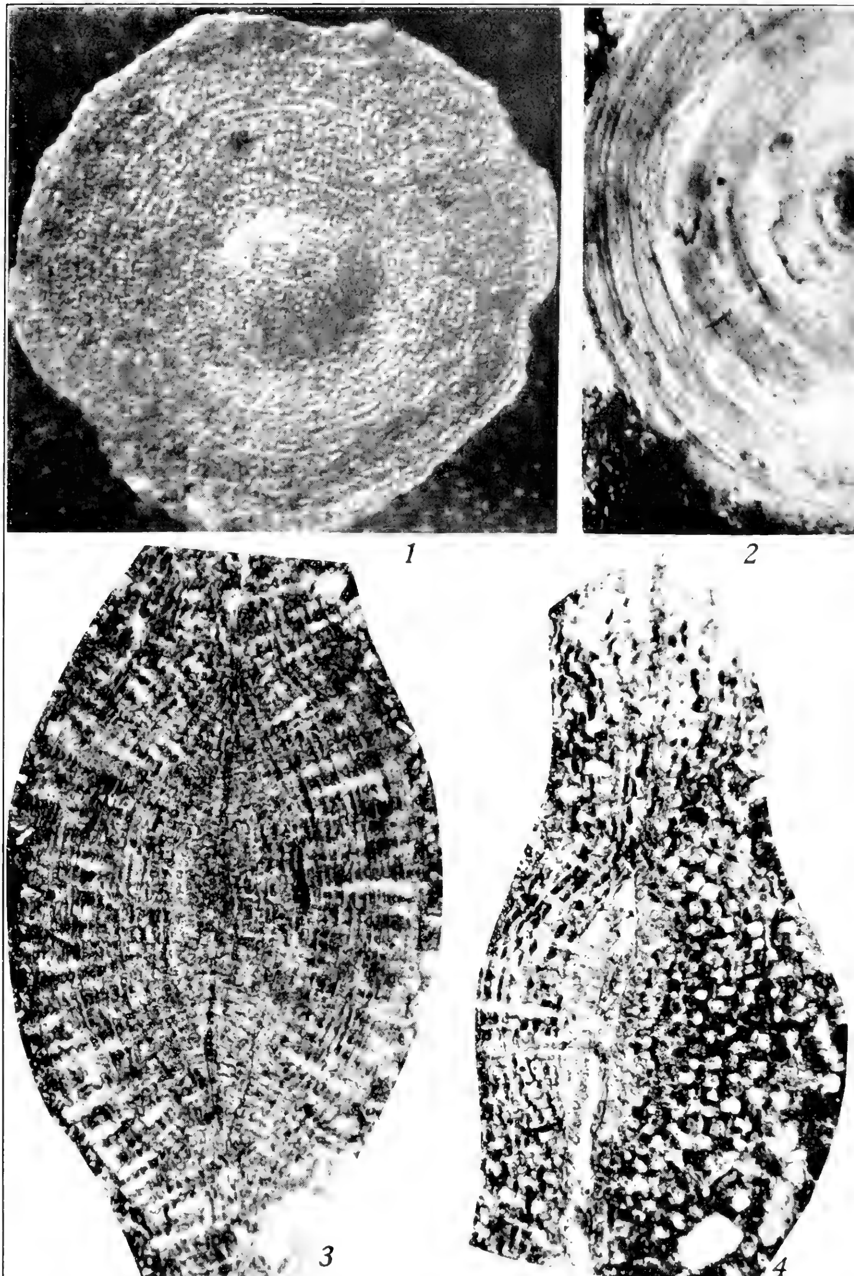

DISCOCYCLINA CUSHMANI

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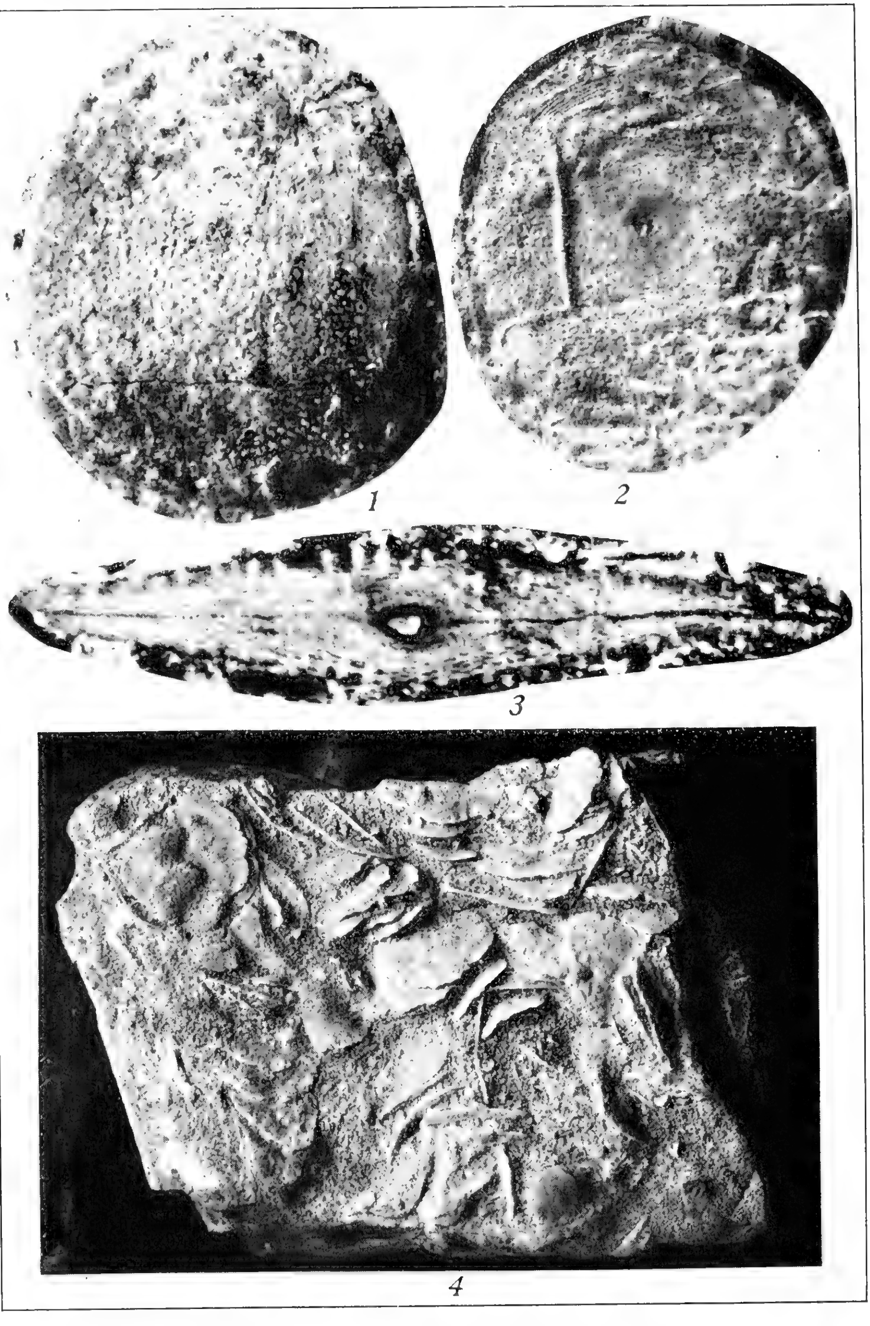

DISCOCYCLINA ZARAGOSENSIS AND D. PALENQUENSIS

FOR EXPLANATION OF PLATE SEE PAGE 18

DISCOCYCLINA CLOPTONI

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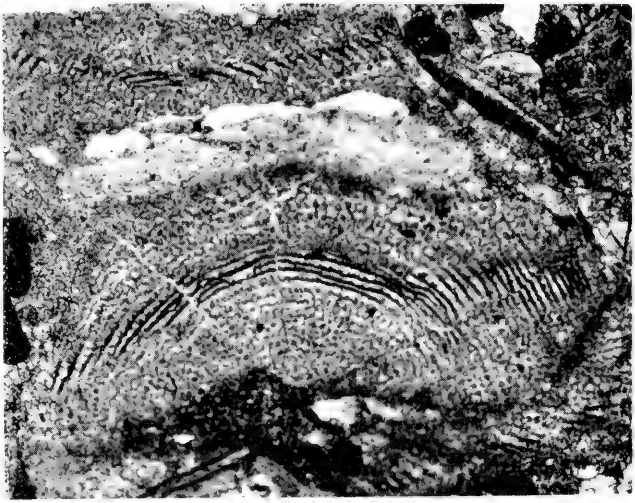

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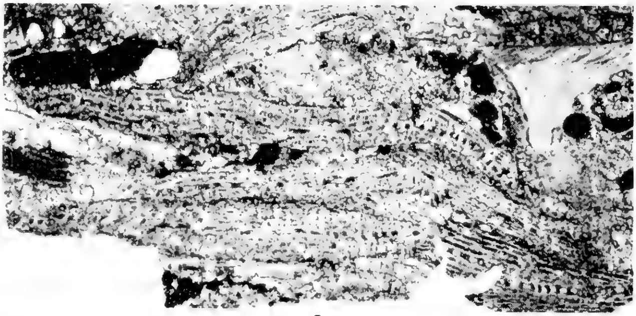

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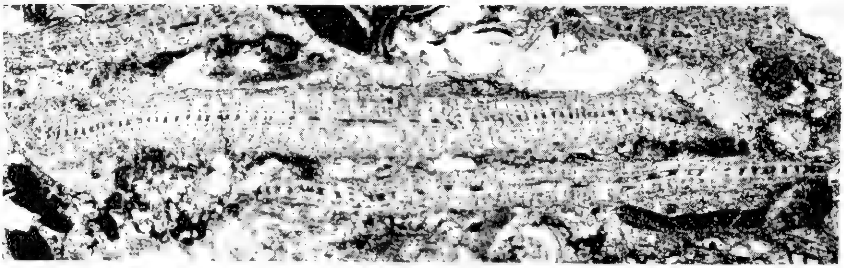

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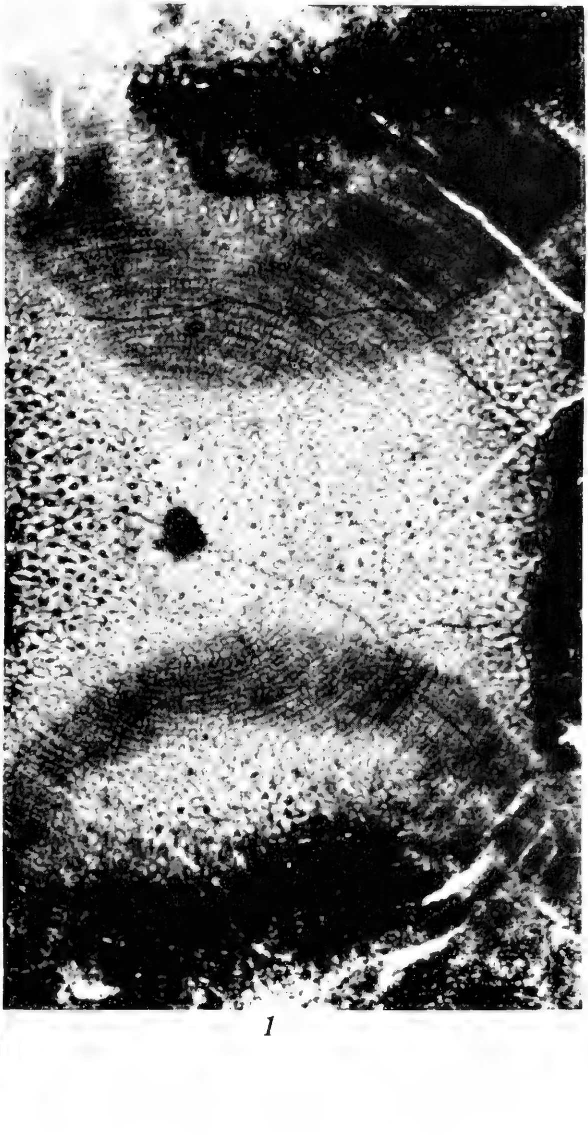
DISCOCYCLINA STEPHENSONI

FOR EXPLANATION OF PLATE SEE PAGE 18



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DISCOCYCLINA PALENQUENSIS

FOR EXPLANATION OF PLATE SEE PAGE 18

NORTH AMERICAN SPECIES OF THE WEEVILS OF THE OTIORHYNCHID GENUS MESAGROICUS

By L. L. Buchanan,
Of the United States Biological Survey

Up to the present time the weevil genus *Mesagroicus* has been recorded only from the palaearctic regions, where a total of about 20 species are known. The single hitherto described American species is *herricki* Pierce, for which its author proposed the unnecessary generic name *Lepidocricus*—*herricki* being closely related to a rather common European species, *Mesagroicus obscurus* Boheman.[1] Pierce's description of *Lepidocricus herricki*, together with two or three subsequent references to it, comprise the entire American literature on the group.

It was of especial interest, therefore, to find among some undetermined material in the United States National Museum collection a considerable number of North American specimens belonging to *Mesagroicus*. These specimens represent several well-marked species, widely distributed over the United States, and doubtless present, in greater or less numbers, in every large beetle collection of the country. Under the circumstances, it seemed worth while to undertake a revisional study of all our native species, in order that a widespread but almost wholly neglected element of the North American weevil fauna may be more generally recognized.

The material examined is largely from the collection of the United States National Museum, supplemented by a number of specimens received from other sources. The writer is indebted in particular to H. F. Wickham and E. T. Cresson, jr., for the loan of material, and to Mary Foley Benson, of the Bureau of Entomology, for the carefully prepared and characteristic drawings of *herricki* and *elongatus*. Types of the species here described as new are deposited, one in the Philadelphia Academy, the remainder (eight) in the National Museum.

Genus MESAGROICUS Schönherr

Mesagroicus Schönherr, Gen. et Sp. Curculionidum, vol. 6, part 1, 1840, p. 281 (Genotype, *Thylacites piliferus* Boheman as designated by Schönherr).—Lacordaire, Gen. Col., vol. 6, 1863, p. 72.—Jacquelin du Val, Gen. des Col.

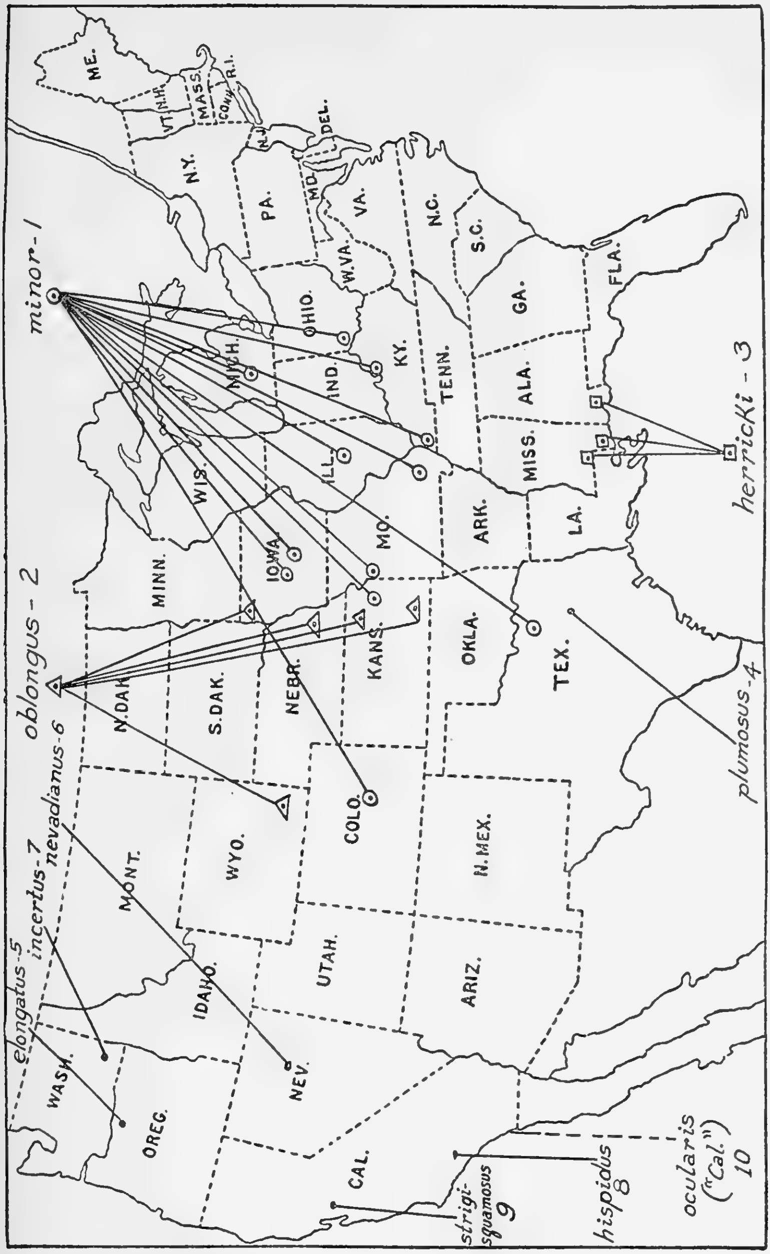
[1] Twelve exotic species of *Mesagroicus* have been examined; two or three of them show a striking superficial resemblance to some of the American species, but no case of actual identity was observed.

d'Europe, 1868, p. 18 (figure of *Mesagroicus obscurus* Boheman, pl. 30, fig. 146).—GEMMINGER and HAROLD, Catalog Coleop., vol. 8, 1871, p. 2203.—REDTENBACHER, Fauna Austriaca: die Käfer, part 2, 1874, p. 196 and CXXXI.—REITTER, Bestim. Tab. eur. Coleop., heft 52, Paskau, 1903.

Lepidocricus PIERCE, Journ. Econ. Ent., vol. 3, 1910, p. 362. (Genotype, *herricki* Pierce, Journ. Econ. Ent., vol. 3, 1910, p. 362, as designated by Pierce).—BLATCHLEY and LENG, Rhyn. of N. E. Amer., 1916, p. 126.—LENG, Cat. Coleop., 1920, p. 314.

Mesagroicus includes rather small (3 to 6 mm. long) plain-looking beetles, with no marked structural or habital peculiarity. The following features are those which have proved useful for recognizing members of the genus: The *Sitona*-like appearance of the head, due to the rounded, convex eyes, the quadrangular, medially grooved rostrum, and the lateral, strongly arcuate scrobes; the unusually short fifth ventral segment; and the rather stout antennae. About half the species (eastern) have a tuberculate pronotum; the remainder (western) have more or less perfectly developed plumose scales on the abdomen. The fore and mid tibiae are generally denticulate along inner edge. The humeri are broadly rounded, and the elytra much wider than the rather small prothorax. Metathoracic wings rudimentary. The punctures on third, fourth, and fifth ventral segments are often much finer and denser than on the first two. With free claws, a scaly and setose body, and lacking prothoracic ocular lobes and vibrissae, *Mesagroicus* traces to the vicinity of *Pantomorus* and *Artipus*, differing from the former by the shorter second funicular segment, etc., and from the latter by the free outer striae of elytra, etc. Other characters are mentioned in the key or illustrated by outline drawings. An erroneous statement in Pierce's generic diagnosis (1910, p. 362) should be corrected here. The rostrum is said to be separated from the head beneath "by very sharp and deep constriction," but, as a matter of fact, the junction of these parts is perfectly normal—about as in *Epicaerus* or *Pantomorus*.

There seem to be no dependable external marks for distinguishing the sexes. When a series of both are present, the males can generally be told by their smaller size, narrower form, more slender beak, longer mucro on hind tibia, and better defined concavity on base of abdomen; the females by their distinctly shorter prothorax and by the transverse concavity on fifth ventral. The latter character, though variable in development and even slightly indicated on occasional male specimens, is perhaps the one most useful for separating the sexes. The tibial mucro is found on all three pairs of legs in the male, and at least on first and second in female; on the hind pair of female it may be present or absent on different specimens of the same species. The median lobe of the male genitalia in the different species shows slight but apparently constant differences.



Distribution of Species of Mesagroicus in the United States

In all the species the scales on certain regions of the body are modified by a more or less complete splitting process, resulting in what are here termed plumose scales.[2] Roughly speaking, three types, or three stages of development, are illustrated within the genus; first, a weakly plumose type, in which only the margin of the scale is affected, giving it a slightly frayed appearance; second, a form in which the normally rounded scale is split entirely to base into a number of filaments; third, a narrow, elongate type which consists of a central stalk from which rise numerous short branches. The most highly developed types have been found on the abdomen of several western species, while, in the eastern species, feebly plumose scales are present on the head, and front and rear coxae, in addition to a few on third, fourth, and fifth, and along rear margins of first and second abdominal segments. In *Mesagroicus*, the plumose scales appear in different stages of development on different parts of the body of the same individual; they are always smaller than the entire scales of the same specimen; they are not present on the dorsum of prothorax or elytra; and the deeply split forms occur in connection with two other features, namely, a more pronounced striation of the elytral scales, and a finer, denser abdominal punctation. With the possible exception of *Trigonoscuta* Motschulsky and *Plenaschopsis* Blaisdell, none of the many North American Otiorhynchid genera examined for this character possess plumose scales approaching the high development shown in several species of *Mesagroicus*.

What little is known of the biologies indicates that the genus is one of general feeders and that some of the species may occasionally become injurious to cultivated plants. The original set of *herricki* Pierce was found damaging young cotton plants, while another specimen of the same species was collected on cowpea. Several specimens of *minor* are labeled as "injuring potatoes"; while *hispidus* was found "feeding on sugar beet" in California.

In the key, *minor* and *oblongus* are separated principally by a difference in the length of the scape, measured across eye. The scape, in its position of rest, lies along the lower margin of the eye, and it is necessary, therefore, to carefully pull or push it up, by means of a needle, until it bisects the eye, in order to accurately determine the relations of the two. This operation is possible without relaxation of the specimen and with little danger of breakage. It is needless to add that the scape, when in the extended position, can not be rotated back to the head without relaxation.

The 10 species and subspecies are divisible into three groups as follows:

[2] Scales of this or a similar nature, which are present on many weevils, have been variously called feathery, plumose, plumate, split, multifurcate, or shaggy by different writers.

1. Basal margin of elytra (the deflexed portion extending downward to the mesonotum) perpendicular, or nearly so, from side to side—about as in *Tanymecus confertus*. (Fig. 17.) Legs setose and also with a coating of large, rounded, appressed scales. Elytral scales dense and broadly overlapping ---------- 2.

1*a*. Surface of elytra, in vicinity of scutellum, sloping gently forward and downward to level of mesonotum, the basal margin perpendicular only at the sides, about as in *Melamomphus alternatus*, etc. (Fig. 18.) Legs with numerous hairs, but without appressed scales, the dense surface punctation plainly visible. Elytral scales rounded, less numerous, and as a rule only narrowly overlapping. Pacific Coast species ---------- Group III.

2. Form rather stout, the elytra slightly inflated behind. Elytral setae truncate at tip, shorter, stouter, in a nearly regular single row along each interval, and, in side view, distinctly curved and inclined. Pronotal tubercles moderately to strongly developed, though sometimes obscured by a surface crust. Eastern species ---------- Group I.

2*a*. Form more slender, subparallel. Elytral setae acute at tip (bristlelike), longer, more numerous and less regular, and more nearly erect. Pronotum not tuberculate. Western species ---------- Group II.

GROUP I (MESAGROICUS sens. str.)

The four species included here are normally some shade of brown in color, with more or less distinct paler markings often showing around upper margin of eyes, sides of prothorax, and on humeri. The elytra are sometimes obscurely and irregularly mottled with darker and lighter blotches. The tarsi and claws are shorter and stouter than in the western species. The plumose scales are few in number and feeble in development (except in *plumosus*). The metepisternal suture is sometimes visible, but frequently is covered by an exudation. The elytral setae may be said to form a single regular row along each interval, although this regularity is only approximate, the setae often becoming slightly uneven or staggered in spots. This tendency toward irregularity is more pronounced in *herricki* and *plumosus* than in the first two species.

KEY TO GROUP I

1. Scales on first and second abdominal segments large (size of elytral scales) and simple; punctures on these two segments moderate to large in size and well separated (figs. 4 and 5); dorsal setae stouter ---------- 2.

1*a*. Abdominal scales minute, plumose; abdominal punctures very small and densely crowded; dorsal setae more slender ---------- 4.

2. Scape, when laid across middle of eye, reaching or slightly passing its hind margin; size smaller, seldom as much as 4 mm.; elytral setae shorter and in a more nearly regular row along each interval ---- **minor**, new species.

2*a*. Scape extending ¾, or slightly more, across eye, but not reaching hind margin; size 4–6 mm.; elytral setae longer ---------- 3.

3. Eyes only moderately convex; pronotal tubercles somewhat irregular in size and shape, and often more or less obscured by a crust; abdominal punctures smaller; pronotum more transverse (25 to 18 in male; 28 to 20 in female—average of 6 specimens of each sex); Middle Western States. **oblongus**, new species.

3*a*. Eyes generally very prominent; rostral sculpture coarser and deeper; pronotal tubercles forming about a hemisphere and nearly always sharply isolated; pronotum less transverse (23 to 19 in male; 27 to 21 in female—average of 6 specimens of each sex); South Atlantic region..... **herricki** Pierce.

4. Eyes large; prothorax relatively small and with conspicuous tubercles. Texas. **plumosus**, new species.

MESAGROICUS MINOR, new species

Eighty-five specimens. Length, 3–4.2 mm. Width, 1.4–2.1 mm. Oblong, scaly covering dense, often also with a thin crust or exudation which more or less obscures the pronotal tubercles and the individual scales of elytra. Scales brown, dorsum of elytra often with some irregular pale and dark blotches, the pale areas rarely extending over most of the upper surface; a band around upper margin of eyes, sides of prothorax, humeral spot, margins of elytra, and undersurface generally paler. Scales on undersurface and on femora with a slight opalescent or coppery luster. Legs and antennae reddish. The pale specimens show dark mottlings on elytra and dark median and sublateral prothoracic stripes. Base of prothorax with a narrow, collarlike constriction extending partly or wholly across dorsum.

Rostrum as long as exserted portion of head, quadrangular in cross section, nearly flat to more or less deeply concave from eyes at least as far forward as the antennal insertion, and also with a narrow median groove which may or may not be continued up on to front of head; nasal plate feeble, surface behind it subglabrous and coarsely sculptured. Sculpture of head and beak, with scales removed, dense and more or less strigose; setae more numerous along sides of rostral sulcus and in a patch above eye. Eyes moderately to strongly prominent, subcircular to oval. Scape feebly biarcuate, slender in basal ¾, distinctly enlarged apically; first funicular segment stouter, ⅓ to ½ longer than second, the latter longer than broad, third to seventh moniliform, seventh broader than sixth but, as a rule, not strongly transverse. Sides of prothorax strongly rounded in female, less so in male, fore and hind margins subtruncate, apex feebly constricted or not; pronotal tubercles small, generally obscured by the crust, but with their punctate and setose summits almost always plainly visible. With scales removed, the tubercles are shown to be uneven in size and shape, with a tendency to run together, some of them formed by the coalescence of several very small tubercles. Elytra with base distinctly emarginate, humeri rounded and merging into the slightly arcuate sides; scutellum minute or invisible, sutural interval sometimes slightly elevated for a short distance near base; elytra not striate, but with regular rows of large, close-set punctures that are so nearly concealed by the scales and crust that they appear as minute black dots; intervals nearly flat, each with a regular row of short setae that are separated by their own length or more; when

denuded, the intervals show a minute but rough punctulation. Abdominal punctures on 1 and 2 larger in male, the shining intervals punctulate and reticulate. Fifth ventral finely and densely punctate. Femora stout, tibiae rather slender, especially in male, anterior pair nearly straight along exterior edge, distinctly bisinuate on inner. Tarsi stout, claws large, metepisternal suture visible or not. Female with a usually distinct transverse depression on fifth ventral. A few feebly plumose scales are present on undersurface and vertex of head, on collarlike production of mesosternum, on fore and rear coxae, etc.

Type.—A male (Cat. No. 41746, U.S.N.M.), 3.6 mm. long, with elongate eyes and distinct rostral sulcus, and 55 paratypes.

Type locality.—Kansas (injuring potato).

Other localities: Kansas (Topeka, Popenoe); Missouri (St. Louis, Soltau), (Kansas City, Soltau), (Cadet, Barlow); Iowa (Iowa City, Wickham), (Ames, Stoner); Illinois; Michigan; Ohio (Cincinnati, Dury); Kentucky (Louisville, Soltau), (Fulton, G. I. Reeves); Texas (Dallas, C. E. Hood); Colorado (Sedalia, Soltau).

Nearly all the external structures of *minor* are subject to considerable or even excessive variation, making it difficult to describe the species in any but indefinite language, or to select key characters that are likely to prove invariably trustworthy. The variations, though so extreme, appear to be true individual differences, since they are not correlated with any marked difference in habitat, and are not substantiated by tangible genitalic differences. Two of the more striking variations affect the eye and the rostral sculpture. The outline of the eye varies from a nearly circular to a distinctly elongate-oval form, with all intergradations. Females show a tendency toward the circular, males toward the oval, type; but there is no constancy in this respect, and individuals of either sex can be found with either form of eye. On the average, the male eye is slightly larger, compared to bulk of head, than in female. The upper surface of beak varies from nearly flat with a fine median groove to broadly and deeply concave; the concavity may end abruptly opposite antennal insertion or may extend nearly to apex. The funicular segments also show inconstancy, the second varying from short and heavy to elongate, though it is never as long or as thick as the first; the seventh segment, in a few specimens, is nearly twice as broad as is normal. The impression on fifth ventral of female is typically rather deep, but becomes shallow in some specimens and, moreover, may be faintly indicated in the male. More or less variation has been noted also in the length of the elytral setae, the thickness of the tibiae, the relative dimensions of the prothorax (irrespective of sex) and the development of the pronotal tubercles. In one or two specimens the abdominal punctures are nearly as large as in *herricki*.

The species collected by Dury at Cincinnati, Ohio, and distributed as *herricki* Pierce, belongs here. The Cincinnati specimens examined are not typical in some respects (the body being stouter, the scape slightly shorter, and the elytral setae longer) and possibly may indicate a local race. The male genitalia, however, are of the normal *minor* form.

The crust or exudation is more pronounced in *minor* than in any of the other species.

MESAGROICUS OBLONGUS, new species

Forty-six specimens. Length, 4–5 mm. Width, 2.01–2.5 mm. Close to *minor* in structure and appearance, but larger. Brown, pale markings as in *minor*, and in addition some specimens with feeble vittae on sutural, third and fifth intervals. Legs, antennae, and often tip of beak, reddish. Scales of ventral surface and legs slightly opalescent. Sculpture of head rather fine, subconfluent, finer than in *minor;* rostrum nearly flat above, with a narrow to coarse median groove which may or may not extend on to head. Rostral sculpture more or less strigose, as in *minor*. Eyes moderately prominent, oval to subcircular. Prothorax relatively shorter, male and female, than in *minor*, the pronotal tubercles larger and better defined, and occasionally leaving a narrow median line free; base with a narrow collar, about as in *minor*. Elytra about as in *minor*, sides straighter, setae slightly longer on the average, the individual scales better defined, due apparently to the absence of a crust. Abdomen about as in *minor*, the punctures slightly smaller, the impression on fifth ventral of female poorly defined, and this impression feebly indicated in some male specimens also. The seventh funicular segment more transverse, on the average, than in *minor*.

Type.—A male (Cat. No. 41747, U.S.N.M.), 4.1 mm. long with faint elytral vittae, and 20 paratypes.

Type locality.—Lincoln, Nebr. (Wickham).

Other localities: Nebraska (Lincoln, Shimek, Soltau, and Hubbard and Schwarz); Wyoming (Cheyenne, Soltau); Kansas (Fort Scott, Soltau), (Onaga, Wickham), (Onaga, Biological Survey, from stomach of meadow lark, *Sturnella magna*); Iowa (Sibley, Stoner), (Lake Okoboji, Buchanan), (Palo Alto County, Biological Survey, from stomach of toad, *Bufo americanus*).

As in *minor*, the proportions of the prothorax vary greatly, irrespective of sex, but in *oblongus* this part is almost always visibly shorter, especially in females. The eyes vary considerably in shape, but on the whole run more to the oval outline than in *minor*. Variations in the funicular segments are about as in that species.

The pronotal tubercles often show two or three small punctures in addition to the large, seta-bearing puncture at summit, indicating

that they are made up of the coalescence of several smaller tubercles. Each main tubercle is covered by from four to six scales.

In this, and the next species, the predominant type of scale on abdomen is simple, but in most specimens a few plumose scales can be detected on third, fourth, or fifth segments. In *minor* the percentage of simple scales is much higher—at least I have seen no specimen of that species with as many plumose scales on abdomen as are often present on the other two.

MESAGROICUS HERRICKI Pierce

Lepidocricus herricki PIERCE, Journ. Econ. Ent., vol. 3, 1910, p. 362; Proc. U. S. Nat. Mus., vol. 45, No. 1988, 1913, p. 420.—BLATCHLEY and LENG, Rhyn. of N. E. Amer., 1916, p. 126 (a composite reference, including data for two more species).—DURY, Bull. Brooklyn Ent. Soc., vol. 18, 1923, p. 27 (probably refers to the species described in this paper as *minor*).

Twenty-two specimens (including three from the original type series). Length, 4–6 mm.; width, 2–2.7 mm. Brown, the pale markings, when present, as in the two preceding except that the dorsum of elytra appears to be normally of a much darker and unmottled brown. About half the specimens with a large pale spot on third interval halfway down the declivity. Rostrum with a broad and deep median sulcus. The prothorax is narrower, compared to elytral width, than in *oblongus*. Measurements of these parts give the following average figures for six males and six females of each species: Width of prothorax is to width of elytra as 22.5 is to 36 (male *herricki*); as 27 is to 46 (female *herricki*); as 24 is to 36 (male *oblongus*); as 27 is to 41 (female *oblongus*). Abdomen coarsely punctate. Compared to *oblongus* and *minor*, *herricki* shows the following differences: Rostrum more deeply sulcate; eyes more prominent (more prominent in male); antennae stouter, the second funicular segment somewhat longer and in a few cases very nearly as long as first; pronotal tubercles much more prominent and more sharply defined; elytral setae longer; abdominal punctures larger; legs heavier, the tibial denticulations coarser.

The deep rostral sulcus, the prominent eyes and pronotal tubercles, and the coarse abdominal punctation are the distinctive characters of this species.

Localities.—Mississippi (Easter, the type locality), (Waveland, Soltau), (Picayune, W. M. Mingee); Alabama (Wadley, H. H. Smith) (Bay Minette, Biological Survey, from stomach of meadow lark).

MESAGROICUS PLUMOSUS, new species

One specimen. Length, 5.2 mm. Width, 2.6 mm. Brown, with pale vittae along sides of prothorax and on humeri. Rostrum as long as head, flat above, median groove narrow, surface either side

strigosely sculptured. Head confluently punctate, eyes large, rather prominent, scape extending ¾ way across middle; seventh funicular segment very strongly transverse. Prothorax unusually short compared to elytra (20 to 67), pronotal tubercles strongly developed, nearly as sharply isolated individually as in *herricki*. Elytra with base deeply emarginate, somewhat depressed in region of scutellum, intervals broad and flat, setae as long as those in *herricki*, but thinner; abdominal scales very small, rounded, feebly to strongly plumose. Fifth ventral (female) with a distinct trasverse impression. Tibiae more dilated apically than in the three preceding species, the denticulations along inner edge feeble. Metepisternal suture fine.

Type.—A female (Cat. No. 41748, U.S.N.M.), labeled "Dept. Ent. Tex. A. & M. C.; A. C. 171."[3]

Type locality.—Texas (probably Mabank).

The plumose scales and fine, dense punctation of abdomen are the distinguishing marks of this species. The elytral setae are slender and some of them, at first sight, appear to be bristlelike, but closer inspection shows that the tip of each is narrowly truncate.

GROUP II

Three species or subspecies comprise this group. The eyes are less convex than in either Group I or III. The scape reaches about ¾ the way across eye. The predominant body scales are simple, although well-developed plumose scales are present on certain areas of the abdomen. The pronotal sculpture is fundamentally of a tuberculate nature, though the tubercles are either so minute as to be properly called granules or so flattened that the resemblance to tubercles is lost.

KEY TO GROUP II

1. Pronotal sculpture consisting of irregular, flat-topped areas (evidently greatly flattened tubercles); prothorax rather narrow (averages 24 broad to 20.5 long) ---------- **elongatus**, new species.
1*a*. Pronotum with shining, punctate granules ---------- 2.
2. Dimensions of prothorax as in *elongatus* ----- var. **nevadianus**, new variety.
2*a*. Prothorax broader (22.5 broad to 18 long) ----- var. **incertus**, new variety.

MESAGROICUS ELONGATUS, new species

Eight specimens. Length, 4.9–5.5 mm.; width, 2.01–2.3 mm. Elongate, slightly broader behind. Color above either uniform cinereous or cinereous and brown, the darker specimens with pale marks along sides of prothorax and on humeri. Antennae and legs reddish. Rostral groove broad and deep, usually extended back on to head, where it is fine. Eyes feebly to moderately convex. First funicular segment distinctly (may be nearly twice) longer than second, third to

[3] H. J. Reinhard, entomologist of the Agricultural and Mechanical College of Texas, has kindly sent the following information regarding accession No. 171: " . . . the specimen (bearing this label) . . . was received from Mr. R. H. Small, Mabank, Tex., on May 5, 1903. No other notes are available, but it appears fairly certain that the specimen was collected in that locality."

sixth moniliform, seventh transverse. Prothorax with sides feebly rounded, widest at or before middle, pronotal tubercles reduced to broad, irregular-shaped, flat-topped, barely elevated areas, each with a seta-bearing puncture, the entire surface normally covered with scales. Elytra with humeri evenly rounded, sides subparallel, sutural intervals, and in one specimen the third and fifth also, slightly prominent from base to middle; intervals broad, nearly flat and each with a row, regular or somewhat confused, of nearly straight, suberect, pale and brown setae; serial punctures small and rather close. Metepisternal suture visible. Abdominal punctures a little smaller than in *oblongus* and well separated. A few plumose scales can be detected here and there over most of the undersurface, but are not conspicuous except on fifth ventral, where they are numerous and deeply split.

Type.—A female (Cat. No. 41749, U.S.N.M.), 5.4 mm. long, and 7 paratypes.

Type locality.—The Dalles, Oreg. (Hubbard and Schwarz).

This species looks considerably like a *Sitona*, due to the elongate, subparallel body and the bristling elytral setae.

MESAGROICUS ELONGATUS var. NEVADIANUS, new variety

One male (Casey collection). Length, 5 mm.; width, 1.9 mm. Shape of *elongatus*, though slightly narrower, scales cinereous, setae pale brown and white. Antennae, eyes, and rostral groove about as in *elongatus*. Pronotal granules not prominent, each with a relatively large puncture occupying nearly the entire summit. Elytral intervals broad, none of them more prominent toward base. Humeri distinctly less prominent than in *elongatus*. First and second abdominal segments broadly concave in male, the concavity with the punctures denser, and the scales more abundantly plumose than in the corresponding area in male *elongatus*. Median lobe of male genitalia as in *elongatus*. Metepisternal suture obscured by scales.

Type locality.—Nevada.

Type.—Cat. No. 41750, U.S.N.M.

MESAGROICUS ELONGATUS var. INCERTUS, new variety

Two specimens (male and female). Length, 4.25–5 mm.; width, 1.7–2.1 mm. Scales brown, elytra with a few, vague, pale mottlings, the usual lateral prothoracic line, upper eye border, and humeral spot pale. Eyes moderately prominent (male) or feebly so (female). First funicular segment fully twice (male) or less than twice (female) length of second; outer segments a little heavier than in *elongatus*. Pronotal granules about as in *nevadianus*. Metepisternal suture well defined. Plumose scales are numerous and highly developed on the abdomen of male but sparse and feebly plumose in female.

Type.—A female (Cat. No. 41751, U.S.N.M.), 4¼ mm. long, and 1 paratype.

Type locality.—Pullman, Wash. (J. W. Hungate, collector.)

GROUP III

Of this group, only four specimens, apparently representing three species, have been seen. The scape extends ¾ way across eye, the latter moderately to strongly prominent. Elytral setae long, fine, acute at tip. Dorsal scales distinctly striate. The scales of under surface are all more or less plumose, those on abdomen being strongly so. Plumose scales are present also on the elytral flanks, a condition not found in either of the preceding groups. The punctures of the entire abdominal surface are small and dense, the species differing in this respect from all the others, except *plumosus*. The tibiae are obsoletely denticulate.

KEY TO GROUP III

1. Elytral scales contiguous to overlapping half their length; form narrow, subcylindrical (prothoracic to elytral width, 24 to 34); elytral setae rather long and conspicuous-------------------------- **hispidus**, new species.

1*a*. Elytral scales, at most, only narrowly overlapping; form stouter-------- 2.

2. Eyes moderately prominent; pronotum with fine, dense, subrugose punctation; elytral setae shorter (prothoracic to elytral width, 26 to 40). **strigisquamosus**, new species.

2*a*. Eyes very prominent, forming a hemisphere; pronotum with punctate granules; elytral setae longer (prothoracic to elytral width, 20.5–34). **ocularis**, new species.

MESAGROICUS HISPIDUS, new species

Two females. Length, 4.9–5.1 mm.; width, 1.8–2 mm. Length to width of pronotum, 3 to 4. Body subcylindrical, a little narrower behind; color pale brown, irregularly mottled with white on elytra. Rostrum with a distinct sulcus from between eyes to antennal insertion, surface either side finely, densely, subconfluently punctured; punctures on head still finer and denser. Eyes moderately prominent. Scape rather thick, distinctly biarcuate, the swollen apical portion setose but not squamose; first funicular segment thicker and longer than second (the two more nearly equal than in next two species), seventh distinctly transverse. Prothorax with sides rather strongly rounded, not constricted apically; pronotum with fine, dense and somewhat irregular punctation. Elytral scales contiguous to overlapping half their length, conspicuously striate, nearly concealing the rows of punctures; each interval with an irregular row of long brown and white setae. Impression on fifth ventral shallow. Plumose scales not so deeply split as in the next two species.

Type.—A female (Cat. No. 41752, U.S.N.M.), 4.9 mm. long, and 1 paratype.

Type locality.—Oxnard, Calif. (Feeding on sugar beet. G. E. Bensel, collector.)

MESAGROICUS STRIGISQUAMOSUS, new species

One female specimen. Length, 5.4 mm.; width, 2.3 mm. Moderately robust, scales coppery, paler as usual along sides of pronotum, upper margin of eyes, and on undersurface. Setae white. Rostral groove shallow basally, deeper in apical half, surface each side densely and roughly punctured; head densely punctured; eyes subcircular, rather prominent. Scape about as in *hispidus;* first funicular segment much stouter than second, and nearly twice as long, seventh more than twice as broad as long. Prothoracic proportions as in *hispidus;* pronotal sculpture consisting of punctate and very feebly elevated remnants of granules which coalesce in places, giving the surface a subrugose and irregular, roughly punctate appearance. Normally, this sculpture would be obscured by the coating of large, rounded, distinctly striate scales. Elytral setae in an irregular single row along each interval, those on fifth interval considerably confused; serial punctures small, largely concealed by the scales. Fifth ventral of female with a well-defined impression.

Type locality.—Altamont, Calif. (C. M. Packard, collector.)

Type.—Cat. No. 41753, U.S.N.M.

MESAGROICUS OCULARIS, new species

One female specimen. Length, 3.9 mm.; width, 1.8 mm. Body robust, less convex than usual, scales brownish coppery, paler around eyes and on undersurface. Head and rostrum, except apical ¼, densely, subconfluently punctate, the latter area with small, unevenly spaced punctures; rostrum lightly concave and with a fine median sulcus. Eyes subcircular. Scape setose, not squamose, in apical half; first funicular segment much stouter and twice as long as second, seventh strongly transverse. Prothorax transverse (5 to 4) sides feebly rounded in basal ⅔, more strongly so toward apex, which is distinctly narrower than base; dorsum flattened for a short distance behind apical margin, pronotum with punctate and setigerous granules, and normally with a coating of rounded, contiguous, striate scales. Elytra deeply emarginate at base, intervals broad and flat; scales large, 3 or 4 together bridging an interval, closely appressed, varying from slightly separated to slightly overlapping, nearly obliterating in places the rows of rather small punctures; setae long, finer and more numerous than usual, in a confused row along each interval. Apical half of last ventral segment with a broad, transverse impression; first and second segments broadly and feebly concave. Undersurface densely and finely punctate.

Type locality.—"Cal." Horn Coll. H. 8308.

Type.—Deposited in Philadelphia Academy of Natural Sciences.

The aspect of this species is one of broadness and flatness. The contiguous or narrowly overlapping elytral scales fail to entirely conceal the surface chitin, which is visible between the scales as numerous, minute, shiny-black points.

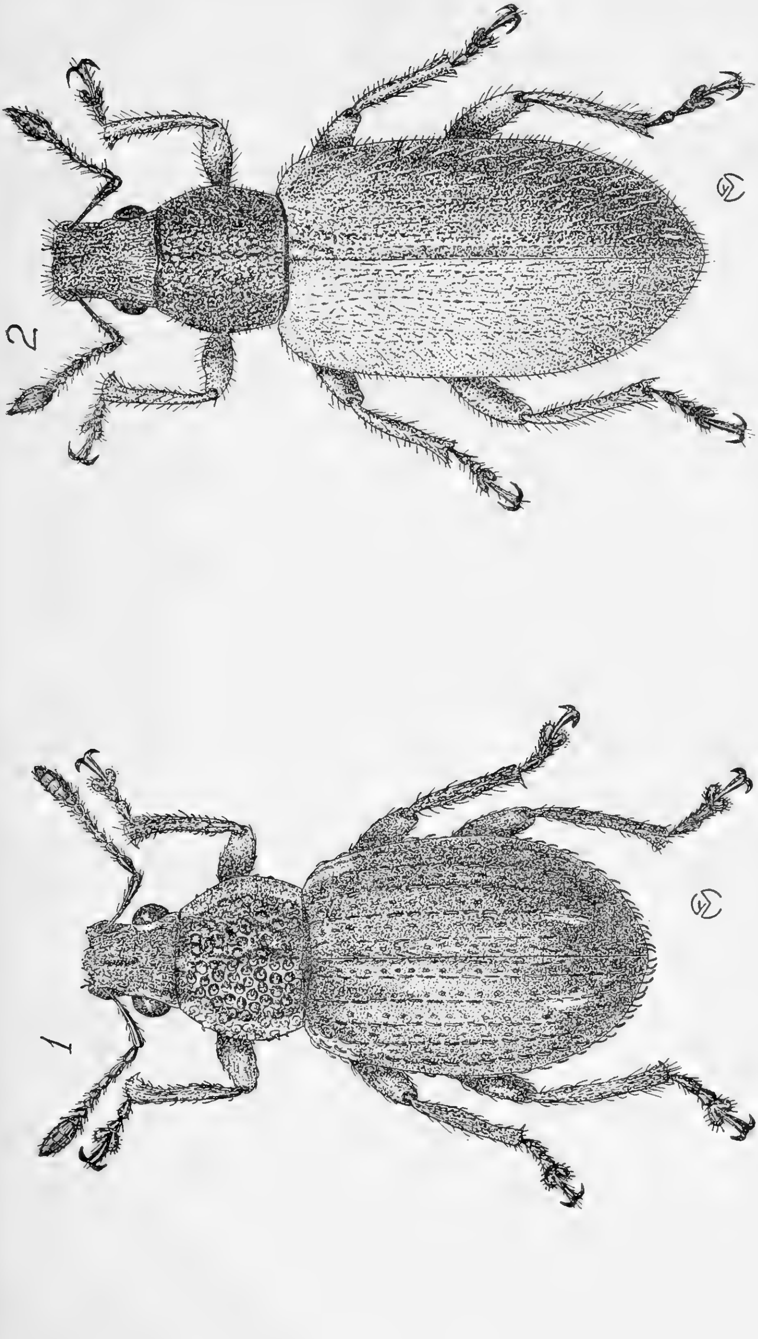
EXPLANATION OF PLATES

Plate 1

Fig. 1. *Mesagroicus herricki*, male.
2. *Mesagroicus elongatus*, female.

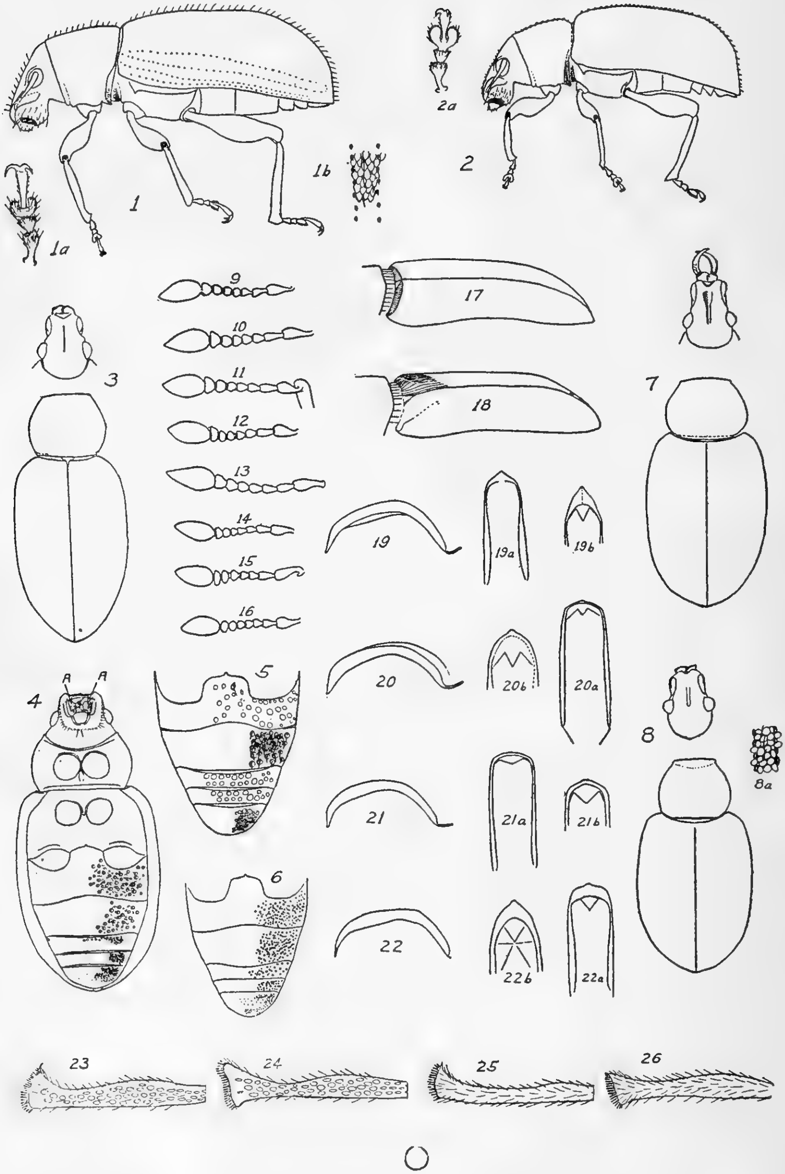
Plate 2

Fig. 1. *Mesagroicus elongatus*, female; 1*a*, fore tarsus; 1*b*, section of an elytral interval, showing scale arrangement.
2. *Mesagroicus minor*, female; 2*a*, fore tarsus.
3. *Mesagroicus hispidus*, female.
4. *Mesagroicus oblongus*; A, mandibular scar.
5. *Mesagroicus herricki*, male abdomen.
6. *Mesagroicus strigisquamosus*, female abdomen.
7. *Mesagroicus minor*, female, with deciduous mandibular piece in place.
8. *Mesagroicus ocularis*; 8*a*, section of an elytral interval, showing scale arrangement.
9–16. Antennae, female, of *minor*, 9; *oblongus*, 10; *herricki*, 11; *plumosus*, 12; *elongatus*, 13; *hispidus*, 14; *strigisquamosus*, 15; and *ocularis*, 16.
17. Diagrammatic sketch to illustrate elytra with a perpendicular basal margin.
18. Same, to show basal margin perpendicular at sides only.
19–22. Median lobe, side view, of male genitalia of *minor*, 19; *oblongus*, 20; *herricki*, 21; and *elongatus*, 22; *a*, dorsal view; *b*, view of apical ¼ of lobe, from a point directly above this portion.
23. Fore tibia of *plumosus*.
24. Hind tibia of same.
25. Fore tibia of *strigisquamosus*.
26. Hind tibia of same.



1. MESAGROICUS HERRICKI (MALE). 2. M. ELONGATUS (FEMALE)

FOR EXPLANATION OF PLATE SEE PAGE 14.



PARTS OF VARIOUS SPECIES OF MESAGROICUS

FOR EXPLANATION OF PLATE SEE PAGE 14.

THREE NEW LAND SHELLS OF THE GENUS OREOHELIX FROM ARIZONA

By William B. Marshall

Assistant Curator, Division of Mollusks, United States National Museum

The study of a collection of *Oreohelix* made by Mrs. Mary Vaux Walcott in the canyon at Supai, Coconino County, Ariz., in 1928, and presented by her to the United States National Museum, not only proved that they belonged to a new subspecies, but their examination entailed a close scrutiny of forms long since contained in our collection but not previously adequately studied. Among these is a new species collected by Dr. Walter Hough in Navajo County, Ariz., and a subspecies of this collected by Dr. E. A. Mearns on Clear Creek, near Winslow, Navajo County, Ariz. All of these are described below.

OREOHELIX YAVAPAI VAUXAE, new subspecies

Plate 1, Figures 1, 2, 3, 11

Shell with spire depressed, flatly conic, height of spire and depth of base about equal. Whorls sharply angulate and bearing on the periphery a prominent white carina which resembles a cord of twisted fibers because of the growth lines crossing it obliquely. This carina begins when the shell has about two whorls. The upper part of the later whorls is attached to the under side of the carina, which therefore fills the suture. It continues on the periphery of the body whorl, but is less marked behind the aperture. Early shell brownish with a few transverse growth lines and a little later with obscure elevated striae, which are obscurely granular and become stronger until about 2½ whorls are completed. At that point the brownish color ceases and is followed by the pale flesh color of the adult shell, and there are several rows of granules spirally arranged, and the whole surface covered with very fine spiral striae, which are most prominent just above the carina. Transverse sculpture of rather strong, retractive growth lines. Umbilicus very wide, showing all the whorls. Base rounded, smoother than the spire, with several spiral rows of minute granules. Aperture continuous, nearly round, lip simple, oblique, very slightly angulated by the periphery, a thick callus across the body whorl. Upper edge of body whorl slightly descending from the

carina at the aperture. Shell flesh color, nearly white, a brown spiral band just above the carina and one below it.

The type and 14 paratypes come from the Canyon at Supai, Coconino County, Ariz., and were collected and presented by Mrs. Charles D. Walcott, whose maiden name has been bestowed upon it.

The dimensions of the type and of those of the paratypes which are adult are as follows, in millimeters:

Cat. No.	Maximum diameter	Minimum diameter	Height	Remarks
380687	23.00	19.75	10.50	Type.
380688	23.25	19.00	10.50	Paratype.
380688	23.00	19.50	10.00	Do.
380688	22.50	18.75	10.25	Do.
380688	21.75	18.00	9.75	Do.
380688	21.50	18.75	9.50	Do.
380688	20.50	18.50	9.75	Do.
380688	21.25	17.50	9.50	Do.
380688	20.00	17.25	8.75	Do.

The prominent characteristics of this shell are the depressed conic spire, the plump round base, the cordlike white carina, the granulated striae, the wide umbilicus, and the two brown bands which show clearly on the general flesh tint of the shell. The specimens appear to be fossil or subfossil, because of the reddish mineral matter coating them in spots. This shell is evidently a subspecies of *Oreohelix yavapai* Pilsbry, the type of which comes from Yavapai County, which adjoins Oconino County. It is much larger than *Oreohelix yavapai* but has essentially the same sculpture. In dimensions it approaches but is slightly larger than *Oreohelix yavapai mariae* Bartsch, the type locality of which is near the mouth of Gallatin Canyon, Mont. Its sculpture is much more pronounced than that of *Oreohelix yavapai mariae,* in which the sculpture usual to the group is not clearly defined.

OREOHELIX HOUGHI, new species

Plate 1, Figures 7, 8, 9, 10

Shell depressed, low conic, upper surface of whorls slightly rounded. Early whorls (as shown by young shells) sharply angled, and with a white cordlike keel which fills all the sutures to the aperture, in front of which the keel disappears but the periphery for a short distance remains angular. On the back of the body whorl the angle fades out and just behind the aperture the whorl is well rounded. Upper part of each whorl attached to under side of the carina. Earliest whorls brownish, with a number of transverse riblets. Later growth pallid, with periodic transverse stripes which continue across the base to the umbilicus. Base nearly white. A faint narrow brown band just below and one just above the periphery. Spiral sculpture lacking. Transverse sculpture of numerous fine retractive growth riblets.

Base rounded, nearly smooth, polished. Aperture oblique, nearly round, a moderate callus across the body whorl. Umbilicus wide, showing all the whorls.

The type (Cat. No. 380689, U.S.N.M.) measures: Maximum diameter, 17.5 mm.; minimum diameter, 15 mm.; height, 9.5 mm., and comes from Heber, Navajo County, Ariz. It and numerous paratypes (Cat. No. 334603, U.S.N.M.) were collected and presented by Dr. Walter Hough of the National Museum, for whom the species is named.

The largest of the paratypes measures: Maximum diameter, 21.75 mm.; minimum diameter, 19 mm.; height, 12 mm.

In depressed form and cordlike carina, this species resembles *Oreohelix yavapai* Pilsbry but lacks spiral sculpture and granules. Nearly all the paratypes are bleached and have lost the brown spiral band above and below the periphery.

OREOHELIX HOUGHI WINSLOWENSIS, new subspecies

Plate 1, Figures 4, 5, 6, 12

Similar to *Oreohelix houghi*, but averaging smaller and slightly more elevated. The corded carina is almost lacking but usually occurs for a short distance in the suture of the third whorl, and the body whorl is rounded.

The type (Cat. No. 380690, U.S.N.M.) measures: Maximum diameter, 19.5 mm.; minimum diameter, 17.5 mm.; height, 11.75 mm. It and 28 paratypes (Cat. No. 181309, U.S.N.M.) come from Clear Creek, near Winslow, Navajo County, Ariz., and were collected and presented by the late Dr. Edgar A. Mearns. The National Museum collection contains also 22 specimens from 12 miles south of St. Johns, in Apache County (Cat. No. 225973, U.S.N.M.); 2 specimens from Holbrook, Navajo County (Cat. No. 151459, U.S.N.M.); 5 specimens from near Canyon Diablo, Coconino County (Cat. No. 198518, U.S.N.M.); 13 specimens from Hardscrabble Draw, near Zuni Sacred Lake, Apache County (Cat. No. 341772, U.S.N.M.); and 25 specimens from Coon Mountain Crater, near Flagstaff, Coconino County. From this list of localities it will be seen that the species inhabits the valley of the Little Colorado River or its immediate vicinity.

EXPLANATION OF THE PLATE

FIGURES 1, 2, 3. *Oreohelix yavapai vauxae*, new subspecies, natural size.
4, 5, 6. *Oreohelix houghi winslowensis*, new subspecies, natural size.
7, 8, 9. *Oreohelix houghi*, new species, natural size.
10. *Oreohelix houghi*, new species, 10 diameters.
11. *Oreohelix yavapai vauxae*, new subspecies, 10 diameters.
12. *Oreohelix houghi winslowensis*, new species, 10 diameterr.

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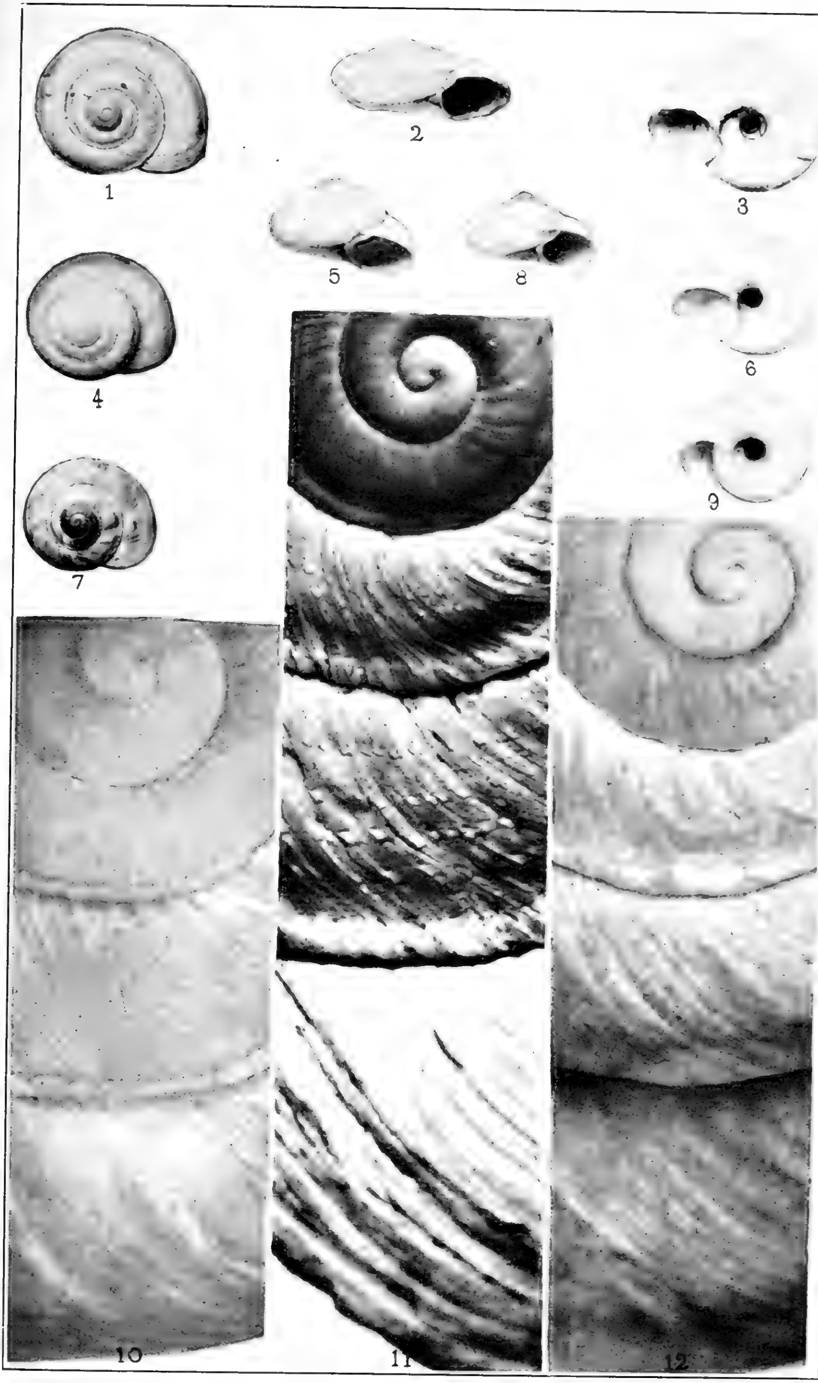

NEW LAND SHELLS OF THE GENUS OREOHELIX

FOR EXPLANATION OF PLATE SEE PAGE 3

NEW SPECIES OF BUPRESTID BEETLES FROM COSTA RICA

By W. S. Fisher

Of the Bureau of Entomology, United States Department of Agriculture

In working over a collection of Buprestid beetles collected in the vicinity of San Jose, Costa Rica, by Ferd. Nevermann, a number of apparently undescribed species have been found; these are described in the present paper. Through the kindness of Mr. Nevermann the types of all the new species have been placed in the collection of the United States National Museum.

AGRILUS TRYPANTIFORMIS, new species

Male.—Elongate, rather broad, shining, and strongly flattened above; head aeneous in front and becoming brownish cupreous on the occiput; pronotum and elytra piceous, with distinct greenish, violaceous and cupreous reflections, and the latter ornamented with distinct white pubescent designs; beneath aureo-cupreous, and more shining than above.

Head with the front wide, very uneven, about equal in width at top and bottom, the lateral margins parallel, with a narrow transverse depression behind the epistoma, the depression deeper at lateral margins, a broad, very deep, somewhat triangular depression on the front extending to the lateral margins, and connected to the transverse depression by a broad, deep, longitudinal depression, causing a large, round gibbosity on each side behind the antennal cavities; surface nearly glabrous, obsoletely reticulate, coarsely, irregularly punctate, and some of the punctures confluent; epistoma transverse between the antennae, deeply, broadly depressed, and broadly, arcuately emarginate in front; antennae extending to base of pronotum, serrate from the fourth joint, and the outer joints distinctly longer than wide; eyes moderately large, broadly oblong, and equally rounded above and beneath.

Pronotum one-half wider than long, about equal in width at apex and base, and widest at basal fourth; sides obliquely expanded from

apical angles to basal fourth, where they are broadly rounded, then more strongly obliquely narrowed to the posterior angles, which are obtusely angulated; submarginal carina visible from above anteriorly, and when viewed from the side the marginal carina is strongly sinuate, the submarginal carina feebly sinuate, the two carinae widely separated anteriorly, and connected to each other at basal fourth; anterior margin strongly sinuate, with the median lobe strongly, broadly rounded; base feebly, broadly emarginate at middle of each elytron, the median lobe strongly produced, and arcuately emarginate in front of the scutellum; disk uneven, with a large, deep, concave median depression extending from anterior margin to base, the depression deeper and broader posteriorly, a deep, narrow depression extending along lateral margins to middle, then irregularly backward and terminating in a deep pitlike puncture at basal emargination, and with a large, strongly elevated round swelling in place of the prehumeral carina; surface coarsely, irregularly punctate, the punctures more or less confluent toward the sides and in the depressions, somewhat rugose, and without distinct pubescence. Scutellum not transversely carinate, but the surface feebly reticulate.

Elytra slightly wider than pronotum at base, and equal in width at base and apical third; sides nearly parallel to apical third (very broadly, vaguely constricted at middle), then obliquely narrowed to the tips, which are separately broadly rounded, and coarsely serrulate; disk strongly, broadly depressed along sutural margins, which are feebly elevated near apex, with broad, deep basal depressions, and each elytron with a vague, broadly obtuse costa extending from humerus to behind middle; surface irregularly, obsoletely punctate, more densely punctured in the pubescent areas, vaguely rugose toward the sides, and each elytron ornamented with white pubescent designs as follows: A small, round spot near sutural margin at basal fourth, a larger spot enclosing a dark area along sutural margin at middle, an irregular spot behind it along the lateral margin, a large oblong spot enclosing a dark area along sutural margin at apical fifth and connected to an irregular spot extending to lateral margin, and a small spot at apex.

Abdomen beneath finely, sparsely punctate, the punctures more or less connected transversely on basal segment, sparsely clothed with very short white hairs, and the last three segments with a spot of more densely placed hairs at the sides; sides only feebly exposed above; first segment convex and without longer hairs at middle; last segment broadly rounded at apex; suture between first and second segments not visible; vertical portions of segments slightly more densely pubescent than ventral surface; pygidium without a project-

ing carina at apex. Prosternum finely, rather densely punctate or rugose, and sparsely clothed with long, erect inconspicuous hairs; prosternal lobe rather broad, vaguely declivous, and very broadly, feebly emarginate in front; prosternal process broad, feebly expanded behind the coxal cavities, then obliquely narrowed to the apex, which is obtusely rounded. Tibiae slender, nearly straight, and the anterior and middle pairs armed with a short tooth on inner margin at apex. Posterior tarsi distinctly shorter than tibiae, and the first joint as long as the following two joints united. Tarsal claws similar on all feet, cleft near middle, the inner tooth short and broad, and not turned inward.

Length, 10.75 mm.; width, 2.75 mm.

Female.—Differs from the male in being broader and more robust, front of head uniformly cupreous, antennae slightly shorter, and the prosternum more coarsely punctured and not clothed with long erect hairs.

Length, 12.5 mm.; width, 3.75 mm.

Type locality.—San Jose, Costa Rica.

Type and *allotype.*—Cat. No. 41604, U.S.N.M.

Described from two examples, male and female, collected on *Erythrina rubrinervia*, at the type locality, July 8, 1923, by Ferd. Nevermann.

This species is allied to *oculatus* Waterhouse described from Mexico, but *oculatus* differs from it in having the pronotum transversely depressed along the base, with the sides only feebly rounded, the elytra expanded behind the middle, and the surface fuscous, strongly shining, and ornamented with numerous aeneous spots and markings which are finely rugose. The species resembles in form some of the species of the genus *Trypantius.*

AGRILUS RAVENTAZONUS, new species

Female.—Elongate, slender, subopaque, and strongly flattened above; above brown, with a more or less cupreous tinge, the head slightly more reddish cupreous, and the elytra ornamented with white pubescent designs; beneath brown, with distinct aeneous and cupreous reflections, and more shining than above.

Head with the front rather wide, slightly convex, vaguely wider at top than bottom, the lateral margins feebly, arcuately expanded at middle, a moderately deep depression extending from occiput to middle of front, the depression deeper and broader on vertex, and with a shallow, elongate, triangular depression behind the epistoma; surface glabrous, more or less longitudinally rugose on occiput and vertex, sparsely, irregularly punctate on lower half, and more densely and finely punctate in the triangular depression; epistoma slightly

transverse between the antennae, and the anterior margin semicircularly emarginate at middle and truncate on each side of the emargination; antennae broken, serrate from the fourth joint, and the outer joints about as wide as long; eyes large, broadly oblong, and about equally rounded above and beneath.

Pronotum nearly one-half wider than long, slightly narrower at base than apex, and widest along apical half; sides nearly parallel from apical angles to middle, then slightly narrowed to near the posterior angles, which are rectangular; when viewed from the side the marginal and submarginal carinae are strongly sinuate, widely separated anteriorly, and connected to each other behind the middle; anterior margin slightly sinuate, and the median lobe feebly, broadly rounded; base angularly emarginate at middle of each elytron, the median lobe strongly produced, broadly rounded, and subtruncate in front of scutellum; disk with two large, feeble depressions placed longitudinally at middle, a broad, deep depression on each side along lateral margin, and with rather strongly elevated, arcuate prehumeral carinae extending from posterior angles to marginal carinae at middle; surface densely, coarsely, transversely rugose at middle, the rugae becoming more oblique toward the sides, and sparsely, finely punctate between the rugae. Scutellum strongly, transversely carinate, and the surface finely reticulate.

Elytra about as wide as pronotum at base, and distinctly wider at base than behind the middle; sides nearly parallel for a short distance behind base, feebly narrowed to behind middle (vaguely constricted in front of middle), then more strongly, obliquely narrowed to near the tips, which are vaguely expanded, broadly subtruncate, and armed with three coarse teeth on each tip, of which the middle tooth is the longest; disk broadly, moderately deeply depressed along sutural margins, causing a more or less distinct longitudinal costa at middle of each elytron, sutural margins slightly elevated toward apex, and with broad, deep basal depressions; surface finely, densely imbricate-punctate, sparsely clothed with short inconspicuous hairs, and each elytron ornamented with white pubescent designs as follows: A small spot in basal depression, an elongate ring in sutural depression in front of middle, a similar ring in same depression behind middle, an elongate spot near apex, and a similar spot along lateral margin behind middle.

Abdomen beneath rather densely, finely punctate, the punctures more or less connected transversely by vague sinuate lines, especially on basal segment, very sparsely clothed with short, inconspicuous hairs, and with a spot of more distinct hairs at the sides of the third and fourth segments; sides very broadly and abruptly exposed above;

first segment convex and without long pubescence at middle; last segment rather acutely rounded at apex; suture between first and second segments not visible; vertical portions of the third and fourth segments clothed with a more or less distinct pubescent spot; pygidium rather strongly carinate anteriorly, but the carina not projecting at apex. Prosternum sparsely, coarsely punctate, more finely anteriorly, and sparsely clothed with short, inconspicuous hairs; prosternal lobe broad, moderately declivous, and broadly rounded in front; prosternal process broad, expanded behind the coxal cavities, then abruptly narrowed to the apex, which is bent upward and acute. Tibiae slender, the anterior pair slightly arcuate, and armed with a short tooth on inner margin at apex. Posterior tarsi distinctly shorter than tibiae, and the first joint as long as the following three joints united. Tarsal claws cleft near middle, the teeth slender, and the inner ones slightly shorter than outer ones, and turned inward, but their tips distant (claws missing on posterior tarsi).

Length, 9.75 mm.; width, 2.5 mm.

Type locality.—Hamburg farm, which is situated on the Raventazon River about midway between Siquires and the coast, in Costa Rica.

Type.—Cat. No. 41612, U.S.N.M.

Described from a single female collected at light at the type locality, May 5, 1923, by Ferd. Nevermann.

AGRILUS OCHRACEOMACULATUS, new species

Female.—Elongate, slender, feebly shining, and slightly flattened above; head green in front, becoming greenish black on the occiput; pronotum and elytra black, with a distinct purplish tinge, and the latter ornamented with distinct orange yellow pubescent designs; beneath aeneous except the prosternum, which is brownish black, and more shining than above.

Head with the front rather wide, feebly convex, slightly wider at top than bottom, the lateral margins feebly obliquely expanded from bottom to top, and with a very broad, shallow concave depression extending from occiput to epistoma; surface finely granulose, rather densely, coarsely punctate, somewhat rugose, and with a few white hairs behind the epistoma; epistoma not transverse between the antennae, broadly, arcuately emarginate in front, and the surface coarsely rugose; antennae extending about to middle of pronotum, serrate from the fourth joint, and the outer joints as wide as long; eyes large, broadly oblong, and equally rounded above and beneath.

Pronotum slightly wider than long, slightly wider at apex than base, and widest at apical third; sides vaguely arcuately rounded from

apical angles to near middle, then more strongly obliquely narrowed to near the posterior angles, which are feebly expanded, and rather acute; when viewed from the side the marginal carina is strongly sinuate, the submarginal carina feebly sinuate, the two carinae widely separated anteriorly, and connected to each other near base; anterior margin feebly sinuate, and the median lobe broadly rounded; base angularly emarginate at middle of each elytron, the median lobe feebly produced, and broadly, arcuately emarginate in front of scutellum; disk broadly, transversely, obsoletely depressed near apex and base, a broad, deep depression on each side along lateral margin, and with strongly elevated, sinuate prehumeral carinae, extending from posterior angles to marginal carinae at middle; surface glabrous, finely but not closely, transversely rugose at middle, becoming more irregularly rugose toward the sides, and finely, sparsely punctate between the rugae. Scutellum moderately, transversely carinate, and the surface finely reticulate.

Elytra about as wide a pronotum at base, and equal in width at base and behind middle; sides nearly parallel for a short distance behind base, broadly, arcuately constructed in front of middle, broadly, arcuately expanded behind middle, then obliquely narrowed to the tips, which are separately, rather narrowly rounded, and finely serrulate; disk vaguely flattened, without longitudinal costae, sutural margins moderately elevated posteriorly, and with broad, deep basal depressions; surface coarsely, densely imbricate-punctate, sparsely clothed with short inconspicuous hairs, and each elytron ornamented with orange yellow pubescent designs as follows: A broad vitta extending along sutural margin from basal fourth to middle, and a slightly oblique, elongate spot at apical fourth.

Abdomen beneath finely, obsoletely reticulate, finely, sparsely punctate, the punctures more or less connected transversely on basal segment, sparsely clothed with short recumbent pubescence, which is denser on each side of middle along anterior margin of basal segment, and with a spot of very dense yellowish pubescence at sides of third segment; sides rather broadly exposed above; first segment convex and without long hairs at middle; last segment broadly rounded at apex; suture between first and second segments not visible; vertical portions of the first segment with a spot of dense orange yellow pubescence; pygidium without a projecting carina at apex. Metasternum and external part of posterior coxae densely clothed with orange yellow pubescence. Prosternum densely granulose, finely but not closely rugose, and sparsely clothed with short, recumbent whitish hairs; prosternal lobe broad, strongly declivous, and broadly subtruncate in front; prosternal process broad, the sides parallel to behind the coxal cavities, then abruptly narrowed to the apex, which is rather acute. Tibiae slender, the anterior pair slightly arcuate and

armed with a minute tooth on inner margin at apex. Posterior tarsi about one-half as long as the tibiae, and the first joint as long as the following two joints united. Tarsal claws similar on all feet, cleft near middle, the teeth slender, and the inner ones slightly shorter than outer ones, turned inward, and their tips nearly touching.

Length, 8.5 mm.; width, 2 mm.

Type locality.—Hamburg farm, Costa Rica.

Type.—Cat. No. 41605, U.S.N.M.

Described from a single female collected at light at the type locality, May 20, 1923, by Ferd. Nevermann.

AGRILUS SESOSTRIS, new species

Female.—Elongate, slender, feebly shining, and slightly flattened above; head aeneous; pronotum purplish red; elytra black, with a vague greenish reflection, subopaque, and each elytron ornamented with a longitudinal pubescent vitta; beneath aeneo-cupreous, and strongly shining.

Head with the front rather wide, feebly convex, distinctly narrower at top than bottom, the lateral margins feebly arcuately expanded at middle and obliquely expanded at bottom, and with a broad, shallow depression on the vertex; surface densely, finely granulose, sparsely punctate, coarsely irregularly rugose, and sparsely clothed with semierect white hairs behind the epistoma; epistoma slightly transverse between the antennae, and broadly, arcuately emarginate in front; antennae extending to middle of pronotum, serrate from the fourth joint, and the outer joints as wide as long; eyes moderately large, broadly oblong, and slightly more acutely rounded beneath than above.

Pronotum slightly wider than long, about equal in width at apex and base, and widest at apical third; sides feebly arcuately rounded from apical angles to behind middle, then parallel to the posterior angles, which are rectangular; when viewed from the side the marginal and submarginal carinae are feebly sinuate, narrowly separated anteriorly, and connected to each other behind the middle; anterior margin strongly sinuate, the median lobe strongly produced, and broadly rounded; base broadly, arcuately emarginate at middle of each elytron, the median lobe feebly produced, and subtruncate in front of scutellum; disk with a very shallow, broad, median depression in front of middle, very broadly, obsoletely transversely depressed behind the middle, a broad, deep depression on each side along lateral margin extending from apical angle to base, and with strongly elevated, straight prehumeral carinae extending from posterior angles to middle, but not connected to the marginal carinae; surface rather coarsely, closely, irregularly rugose, finely, sparsely punctate between the rugae, and densely clothed with recumbent

golden yellow pubescence in the lateral and anterior median depressions. Scutellum strongly, transversely carinate, and the surface finely reticulate.

Elytra slightly wider than pronotum at base, and equal in width at base and behind middle; sides nearly parallel for a short distance behind base, broadly, arcuately constricted in front of middle, broadly, arcuately expanded behind the middle, then obliquely narrowed to the tips, which are separately, rather narrowly rounded, and strongly serrulate; disk feebly, broadly depressed along sutural margins, causing a more or less distinct longitudinal costa at middle of each elytron, sutural margins distinctly elevated toward apex, and with broad, moderately deep basal depressions; surface finely, densely imbricate-punctate, sparsely clothed with short inconspicuous hairs, and each elytron ornamented with a broad, yellowish white pubscent vitta extending along the sutural depression from the basal depression to near apex.

Abdomen beneath obsoletely reticulate, finely, rather densely punctate, the punctures more or less connected transversely by sinuate lines at sides of segments, sparsely clothed with short inconspicuous hairs at middle, but more densely clothed with longer hairs at the sides; sides narrowly exposed above; first segment convex and without long hairs at middle; last segment broadly rounded at apex; suture between first and second segments indicated at the sides; vertical portions of the segments nearly glabrous; pygidium longitudinally carinate, but the carina not projecting at apex. Prosternum sparsely, finely punctate, somewhat rugose, and sparsely clothed with short recumbent hairs; prosternal lobe broad, moderately declivous, and broadly rounded in front; prosternal process broad, the sides parallel to behind the coxal cavities, then obliquely narrowed to the apex, which is acute. Tibiae slender, straight, and without a distinct tooth on inner margin at apex. Posterior tarsi about one-half as long as the tibiae, and the first joint subequal in length to the following joints united. Tarsal claws similar on all feet, cleft near the middle, the inner tooth broader and much shorter than outer one and not turned inward.

Length, 8.25 mm.; width, 1.8 mm.

Type locality.—Hamburg farm, Costa Rica.

Type.—Cat. No. 41606, U.S.N.M.

Described from a single female collected on flowers at the type locality, November 30, 1924, by Ferd. Nevermann.

AGRILUS NEVERMANNI, new species

Female.—Small, slender, strongly acuminate posteriorly, feebly shining, and strongly flattened above; head bright cupreous red, becoming bronzy green at bottom and on epistoma; pronotum bright

cupreous red, except the basal third, which is bright green; elytra bluish black, and ornamented with yellowish white pubescent designs; beneath piceous, with a vague aeneous or cupreous reflection, and more shining than above.

Head with the front rather narrow, about equal in width at top and bottom, the lateral margins nearly parallel, and with a large, round, deep depression behind the epistoma; surface nearly glabrous, coarsely, irregularly rugose, and finely, sparsely punctate between the rugae; epistoma transverse between the antennae, and very broadly arcuately emarginate in front; antennae extending nearly to base of pronotum, serrate from the fourth joint, and the outer joints longer than wide; eyes large, broadly oblong, and slightly more acutely rounded beneath than above.

Pronotum only vaguely wider than long, wider at apex than base, and widest near middle; sides feebly arcuately rounded from apical angles to posterior angles, which are rectangular; when viewed from the side the marginal carina is straight, the submarginal carina strongly bisinuate, the two carinae narrowly separated anteriorly, and connected to each other behind the middle; anterior margin strongly sinuate, the median lobe strongly produced and broadly rounded; base feebly emarginate at middle of each elytron, the median lobe feebly produced, and broadly subtruncate in front of scutellum; disk strongly convex anteriorly, broadly transversely concave on basal half, the concavity extending narrowly along the lateral margins to apical angles, a small round depression near posterior angles, and without prehumeral carinae; surface obsoletely granulose, finely but not closely rugose, the rugae more or less concentrical anteriorly, transverse on basal half, finely, sparsely punctate between the rugae, and with a few short hairs near posterior angles. Scutellum strongly, transversely carinate, and the surface finely reticulate.

Elytra wider than pronotum at base, and distinctly wider at base than behind middle; sides feebly arcuately rounded for a short distance behind base, broadly arcuately constricted in front of middle, broadly arcuately expanded behind the middle, then strongly obliquely narrowed to the tips, which are conjointly angularly emarginate, and strongly serrulate; disk with a rather broad, elongate depression along sutural margins in front of middle, sutural margins feebly elevated posteriorly, and with broad, deep basal depressions; surface densely, coarsely imbricate-punctate, sparsely clothed with short inconspicuous hairs, and each elytron ornamented with yellowish white pubescent designs as follows: A small spot in basal depression, a broad vitta along sutural margin extending from basal fourth to middle, where it is expanded transversely, but not reaching the lateral margin, and the apical fourth sparsely clothed with simi-

lar colored hairs, which extend narrowly along the sutural margin to the broad vitta at middle.

Abdomen beneath finely, sparsely punctate, the punctures connected transversely at middle of basal segment by sinuate lines, somewhat imbricate at sides of basal segment, very sparsely clothed with short white hairs, and with a spot of more densely placed white hairs at sides of the third segment; sides broadly, abruptly exposed above; first segment convex and without long hairs at middle; last segment rather narrowly rounded at apex; suture between first and second segments not visible; vertical portions of first segment with a spot of densely placed white hairs; pygidium longitudinally carinate anteriorly, but the carina not projecting at apex. Prosternum sparsely, finely punctate, more or less scabrous, and sparsely clothed with short recumbent white hairs; prosternal lobe broad, moderately declivous, and broadly subtruncate in front; prosternal process broad, the sides parallel to behind the coxal cavities, then arcuately narrowed to the apex, which is rather acute. Tibiae slender, anterior pair arcuate, and the anterior and middle pairs armed with a short tooth on inner margin at apex. Posterior tarsi about one-half as long as the tibiae, and the first joint subequal in length to the following joints united. Tarsal claws cleft near middle, the inner tooth broad and shorter than outer one, and not turned inward (claws on anterior feet missing).

Length, 6 mm.; width, 1.25 mm.

Type locality.—Hamburg farm, Costa Rica.

Type.—Cat. No. 41607, U.S.N.M.

Described from a unique female collected on withered leaves at the type locality, April 11, 1926, by Ferd. Nevermann.

I take great pleasure in naming this species after my friend, Ferd. Nevermann, of San Jose, Costa Rica, through whose careful and energetic collecting our knowledge of the interesting fauna of Costa Rica has been very greatly increased.

AGRILUS OBSOLETOVITTATUS, new species

Female.—Small, rather slender, moderately shining, and feebly flattened above; head green, with a vague pinkish reflection behind the epistoma and on occiput; pronotum aureo-aeneous; elytra brownish black, with a vague greenish or aeneous tinge, and each elytron ornamented with a vague longitudinal pubescent vitta; beneath dark brown, with a distinct aeneous or cupreous reflection, and more shining than above.

Head with the front rather wide, feebly convex, distinctly narrower at top than bottom, the lateral margins obliquely expanded from top to bottom, and with a broad, shallow longitudinal depression extending from occiput to epistoma; surface nearly glabrous,

coarsely, densely, irregularly rugose, and with numerous fine punctures between the rugae; epistoma strongly transverse between the antennae, and broadly, vaguely, arcuately emarginate in front; antennae extending to middle of pronotum, serrate from the fifth joint, and the outer joints slightly wider than long; eyes moderately large, not very broadly oblong, but slightly more acutely rounded beneath than above.

Pronotum about one-third wider than long, distinctly wider at apex than base, and widest near apex; sides feebly arcuately narrowed from apical angles to behind middle, then more strongly narrowed to the posterior angles, which are rectangular; when viewed from the side the marginal and submarginal carinae are strongly sinuate, widely separated anteriorly, and connected to each other behind the middle; anterior margin strongly sinuate, the median lobe moderately produced and broadly rounded; base broadly arcuately emarginate at middle of each elytron, the median lobe slightly produced, and arcuately emarginate in front of scutellum; disk with two broad, shallow median depressions, a rather narrow depression on each side along lateral margin, and with strongly elevated, slightly arcuate prehumeral carinae extending from posterior angles to basal third, but not connected to the marginal carinae; surface coarsely, closely, transversely rugose at middle, more obliquely rugose at the sides, finely, sparsely punctate between the rugae, and clothed with a few short yellow hairs in the lateral depressions near apical angles. Scutellum strongly, transversely carinate, and the surface finely reticulate.

Elytra slightly wider than pronotum at base, and about equal in width at base and behind middle; sides nearly parallel for a short distance behind base, vaguely arcuately constricted in front of middle, feebly arcuately expanded behind the middle, then obliquely narrowed to the tips, which are separately narrowly rounded, and strongly serrulate; disk vaguely flattened, without longitudinal costae, sutural margins slightly elevated posteriorly, and with broad, shallow basal depressions; surface densely, finely imbricate-punctate, sparsely clothed with short inconspicuous hairs, and each elytron ornamented with a broad vitta of sparsely placed, short yellowish hairs, the vitta not very conspicuous, and extending from the basal depression to near the apex.

Abdomen beneath obsoletely granulose, finely, rather densely punctate, the punctures more or less connected transversely on basal segment by sinuate lines, and sparsely clothed with very short, recumbent whitish hairs; sides rather broadly exposed above; first segment convex and without long hairs at middle; last segment rather broadly rounded at apex; suture between first and second segments not visible; vertical portions of the segments slightly more densely pubescent

than the ventral surface; pygidium without a projecting carina at apex. Prosternum sparsely, finely punctate, somewhat rugose, and sparsely clothed with short recumbent white hairs; prosternal lobe broad, vaguely declivous, and broadly but not deeply, arcuately emarginate in front; prosternal process broad, the sides parallel to behind the coxal cavities, then arcuately narrowed to the apex, which is rather acute. Tibiae slender, straight, and without a distinct tooth on inner margin at apex. Posterior tarsi distinctly shorter than tibiae, and the first joint as long as the following three joints united. Tarsal claws similar on all feet, cleft near the middle, the inner tooth broad and much shorter than outer one, and not turned inward.

Length, 5.25 mm.; width, 1.25 mm.

Type locality.—San José, Costa Rica.

Type.—Cat. No. 41608, U.S.N.M.

Described from a single female collected on bushes at the type locality, May 22, 1925, by Ferd. Nevermann.

AGRILUS VIRIDICEPHALUS, new species

Male.—Form resembling *obsoletovittatus* Fisher; head bright green, becoming reddish brown on the occiput; pronotum blackish, with distinct greenish blue and purplish reflections; elytra aeneous on basal half of disk, becoming bluish black on apical half and toward lateral margins, and ornamented with yellowish white pubescent designs; beneath dark brown, with a more or less cupreous reflection, more shining than above, and the legs greenish.

Head with the front broad, slightly convex, narrower at top than bottom, the lateral margins feebly arcuately expanded at middle, and obliquely expanded at bottom, and without distinct depressions; surface glabrous, densely, finely granulose, sparsely, coarsely punctate, and longitudinally rugose on the occiput; epistoma transverse between the antennae, and broadly arcuately emarginate in front; antennae extending nearly to base of pronotum, serrate from the fifth joint, and the outer joints longer than wide; eyes large, broadly oblong, and about equally rounded above and beneath.

Pronotum vaguely wider than long, slightly wider at apex than base, and widest near apex; sides feebly arcuately narrowed from apical angles to posterior angles, which are rectangular; when viewed from the side the marginal and submarginal carinae are strongly sinuate, rather narrowly separated anteriorly, and connected to each other near base; anterior margin strongly sinuate, the median lobe strongly produced, and broadly rounded; base arcuately emarginate at middle of each elytron, the median lobe feebly produced, and vaguely arcuately emarginate in front of scutellum; disk without distinct median depressions, but with a broad, very shallow depression on each side along lateral margin, and with strongly elevated,

vaguely arcuate prehumeral carinae, extending from posterior angles to marginal carinae near middle; surface glabrous except for a few short hairs along lateral margins, coarsely, rather closely, transversely rugose at middle, more obliquely rugose at the sides, and sparsely, finely punctate between the rugae. Scutellum strongly transversely carinate, and the surface finely reticulate.

Elytra slightly wider than pronotum at base, and about equal in width at base and behind middle; sides nearly parallel for a short distance behind base, broadly arcuately constricted in front of middle, broadly arcuately expanded behind the middle, then obliquely narrowed to the tips, which are separately, rather broadly rounded, and strongly serrulate; disk with a rather broad, elongate depression along sutural margins in front of middle, sutural margins strongly elevated posteriorly, and with broad, shallow basal depressions; surface finely, densely imbricate-punctate, sparsely clothed with very short inconspicuous hairs, and each elytron ornamented with yellowish white pubescent designs as follows: A small spot in basal depression, a broad vitta along sutural margin extending from basal fourth to middle, where it extends transversely outward, but not reaching the lateral margin, and with numerous scattered hairs over the apical fourth.

Abdomen beneath obsoletely reticulate, finely, sparsely punctate, the punctures more or less connected transversely on basal segment by sinuate lines, and sparsely clothed with short recumbent white hairs; sides narrowly exposed above; first segment convex and without long hairs at middle; last segment broadly rounded at apex; suture between first and second segments not visible; vertical portions of segments not conspicuously pubescent; pygidium without a projecting carina at apex. Prosternum coarsely, densely rugose, somewhat scabrous, and sparsely clothed with short recumbent white hairs; prosternal lobe broad, strongly declivous, and densely clothed with long, erect yellow hairs along anterior margin, which is broadly subtruncate; prosternal process broad and concave, the sides parallel to behind the coxal cavities, then abruptly narrowed to the apex, which is obtusely rounded. Tibiae slender, straight, and the anterior and middle pairs armed with a short tooth on inner margin at apex. Posterior tarsi distinctly shorter than tibiae, and the first joint as long as the following two joints united. Tarsal claws cleft near the middle, the inner tooth broad and much shorter than outer one, and not turned inward (claws on middle and posterior feet missing).

Length, 5.25 mm.; width, 1.2 mm.

Type locality.—Hamburg farm, Costa Rica.

Type.—Cat. No. 41609, U.S.N.M.

Described from a single male collected at light at the type locality, November 15, 1923, by Ferd. Nevermann.

AGRILUS COERULEONIGRA, new species

Female.—Small, very slender, strongly acuminate posteriorly, shining, and rather strongly flattened above; head and pronotum bottle green, and the former with a ruby tinge on the front; elytra bluish or greenish black, and ornamented with pubescent markings; beneath reddish cupreous, and more shining than above.

Head with the front moderately wide, convex, wider at top than bottom, the sides feebly arcuately expanded at middle, and with a rather broad, shallow, longitudinal depression on the occiput and vertex; surface finely, sparsely punctate, becoming coarsely, irregularly rugose toward top, and clothed with a few short hairs behind the epistoma; epistoma very narrow between the antennae, and the anterior margin broadly, deeply, arcuately emarginate at middle; antennae extending scarcely to middle of pronotum, serrate from the fourth joint, and the outer joints as wide as long; eyes very large, broadly oblong, and about equally rounded above and beneath.

Pronotum one-third wider than long, about equal in width at base and apex, and widest at middle; sides arcuately rounded, more strongly posteriorly to near the posterior angles, which are slightly expanded and rather acute; when viewed from the sides the marginal and submarginal carinae are vaguely sinuate, narrowly separated anteriorly, and connected to each other behind the middle; anterior margin slightly sinuate, and the median lobe feebly, broadly rounded; base angularly emarginate at middle of each elytron, the median lobe broadly rounded, feebly produced, and subtruncate in front of scutellum; disk moderately convex, broadly concave along base, the concavity extending along lateral margins, but becoming narrower toward the apical angles, and with strongly elevated, arcuate prehumeral carinae extending from posterior angles to the marginal carinae at middle; surface glabrous, finely but not closely rugose, the rugae more or less transverse at the middle, more oblique toward the sides, and with a few fine punctures between the rugae. Scutellum strongly, transversely carinate, and the surface finely, densely reticulate.

Elytra slightly wider than pronotum at base, and distinctly wider at base than behind middle; sides nearly parallel for a short distance behind base, feebly narrowed to behind middle (vaguely constricted in front of middle), then strongly narrowed to apical sixth, where they are nearly parallel to the tips, which are separately, deeply, acutely emarginate, with the two teeth long, acute, and the inner one distinctly shorter than outer one; disk broadly, vaguely, longitudinally depressed along sutural margins, causing a more or less distinct longitudinal costa at middle of each elytron, sutural margins rather strongly elevated posteriorly, and with broad, moderately deep

basal depressions; surface coarsely but not deeply imbricate-punctate, sparsely clothed with short inconspicuous hairs, and each elytron ornamented with yellowish white pubescent designs as follows: A large elongate spot in sutural depression in front of middle, and a narrower vitta in the sutural depression extending from the apex to just behind the middle, where the vitta is slightly enlarged.

Abdomen beneath finely, sparsely punctate, the punctures coarser and connected transversely by sinuate lines on the basal segment, very sparsely clothed with short recumbent white hairs, and the last three segments with a small spot of denser white hairs at the sides; sides rather broadly exposed above; first segment convex and without long pubescence at middle; last segment rather acutely rounded at apex; suture between first and second segments not visible; vertical portions of first segment with a spot of dense golden yellow pubescence; pygidium longitudinally carinate, but the carina not projecting at apex. Prosternum coarsely rugose, and sparsely clothed with short recumbent hairs; prosternal lobe broad, moderately declivous, and broadly rounded in front; prosternal process broad, slightly expanded behind the coxal cavities, then abruptly narrowed to the apex, which is bent upward and acute. Tibiae slender, straight, and the anterior pair armed with a minute tooth on the inner margin at apex. Posterior tibiae missing. Tarsal claws on anterior and middle feet similar, cleft near middle, the teeth long and acute, the inner one turned inward, and the tip nearly touching that of the opposite side.

Length, 6.25 mm.; width, 1.25 mm.

Type locality.—San José, Costa Rica.

Type.—Cat. No. 41610, U.S.N.M.

Described from a single female collected at the type locality during May, 1922, by Ferd. Nevermann.

AGRILUS TURRIALBENSIS, new species

Female.—Elongate, slender, shining, and strongly flattened above; head reddish cupreous in front but becoming greenish brown on the occiput; pronotum dark olivaceous green, with a feeble purplish reflection toward the lateral margins; elytra greenish black, with a feeble purplish tinge at humeral angles and apex, and ornamented with whitish pubescent spots; beneath piceous, with distinct aeneous and cupreous reflections, and more shining than above.

Head with the front wide, slightly convex, about equal in width at top and bottom, the lateral margins feebly arcuately expanded at middle, and with a broad, deep, longitudinal depression extending from epistoma to occiput; surface coarsely, irregularly rugose, with a few fine punctures between the rugae, except at bottom where the

surface is very sparsely, coarsely, and irregularly punctate, and clothed with whitish pubescence behind the epistoma and antennal cavities; epistoma not transverse between the antennae, but deeply arcuately emarginate in front; antennae extending nearly to middle of pronotum, serrate from the fourth joint, and the outer joints about as wide as long; eyes large, broadly oblong, and equally rounded above and beneath.

Pronotum nearly one-half wider than long, about equal in width at base and apex, and widest at middle; sides slightly arcuately rounded from apical angles to posterior angles, which are rectangular; when viewed from the side the marginal and submarginal carinae are feebly sinuate, rather narrowly separated anteriorly, and connected to each other behind the middle; anterior margin feebly sinuate and without a distinct median lobe; base feebly emarginate at middle of each elytron, the median lobe broadly rounded, and subtruncate in front of scutellum; disk with two large, vague depressions placed longitudinally at middle, a broad, deep depression on each side along lateral margin, and with strongly elevated, arcuate prehumeral carinae extending from posterior angles to marginal carinae at middle; surface coarsely but not deeply transversely rugose at middle, becoming irregularly rugose toward the sides, finely punctate between the rugae, and sparsely clothed with very short whitish hairs in the lateral depressions. Scutellum strongly, transversely carinate, and the surface smooth.

Elytra slightly wider than pronotum at base and distinctly wider at base than behind middle; sides nearly parallel for a short distance behind base, feebly narrowed to behind middle (vaguely constricted in front of middle), then more strongly, obliquely narrowed to near the tips, which are slightly expanded, broadly subtruncate, and coarsely, irregularly dentate; disk broadly, deeply depressed along sutural margins, causing a broadly rounded longitudinal costa at middle of each elytron, sutural margins distinctly elevated posteriorly, and with broad, deep basal depressions; surface vaguely rugose, sparsely, finely punctate, sparsely clothed with short inconspicuous black hairs, and each elytron ornamented with whitish pubescent spots as follows: Four elongate spots placed in the sutural depression, one at base, one in front of middle, one behind middle, and one near apex, and an additional elongate spot along lateral margin behind middle.

Abdomen beneath finely, sparsely punctate, the punctures more or less connected transversely by vague sinuate lines on basal segment, sparsely clothed with short inconspicuous hairs, and with a large spot of white pubescence at sides of third segment; sides very broadly, abruptly exposed above; first segment convex and without long pubescence at middle; last segment broadly rounded at apex;

suture between first and second segments not visible; vertical portions of all segments except the second clothed with distinct spots of white pubescence; pygidium broadly sinuate at apex, but without a projecting carina. Prosternum sparsely, coarsely punctate, more finely anteriorly, and clothed with short, recumbent white hairs; prosternal lobe broad, moderately declivous, and broadly, vaguely emarginate in front; prosternal process broad, feebly expanded behind the coxal cavities, then abruptly narrowed to the apex, which is bent upward and acute. Tibiae slender, the anterior pair slightly arcuate, and armed with a very short tooth on inner margin at apex. Posterior tarsi distinctly shorter than tibiae, and the first joint as long as the following three joints united. Tarsal claws nearly similar on all feet, cleft near middle, the teeth slender, and the inner ones slightly shorter than outer ones and turned inward, but their tips distant.

Length, 11.75 mm.; width, 2.75 mm.

Type locality.—San Jose, Costa Rica.

Type.—Cat. No. 41611 U.S.N.M.

Described from a single female collected on "guava leaves (*Inga* sp.)" at the type locality, September 1, 1926, by Ferd. Nevermann. This is not the guava found in the southern part of the United States, which belongs to the genus *Psidium* and known under the name of guava by the English-speaking peoples, but is the Spanish name for various species belonging to the genus *Inga* found in Central America, where it is considered the best tree for shading the coffee plants.

TAPHROCERUS BREVICARINATUS, new species

Elongate, more strongly attenuate posteriorly, moderately convex, feebly flattened above, and nearly glabrous; above uniformly aeneous; beneath piceous, with a strong aeneous tinge.

Head much narrower than pronotum at base, strongly convex from top to bottom, nearly flat transversely, the lateral margins vaguely wider at top than bottom, and with a broad, longitudinal, very shallow concave depression extending from epistoma to middle of front; temple about one-third as wide as the transverse diameter of the eye; surface obsoletely reticulate, and glabrous.

Pronotum moderately convex, nearly twice as wide as long, distinctly wider at base than apex, and widest at base; sides when viewed from above obliquely expanded from apical angles to posterior angles, which are nearly rectangular; anterior margin transversely truncate; base transversely truncate to middle of each elytron, with the median lobe feebly produced and vaguely emarginate in front of scutellum; disk with a narrow transverse depression behind the anterior margin, broadly depressed along lateral margins, and

broadly, deeply, transversely concave on basal half, the concavity more shallow in front of the scutellum; surface obsoletely reticulate, and with a few scattered, inconspicuous ocellate punctures in the depressions. Scutellum small, triangular, obsoletely granulose, and feebly arcuately rounded in front.

Elytra feebly convex above, about as wide as pronotum at base, and equal in width at base and middle; humeral angles obtusely angulated; sides obliquely expanded from base to basal sixth, arcuately constricted at basal fourth, broadly arcuately rounded at middle, then obliquely narrowed to near the tips, which are conjointly, rather broadly rounded, and finely, irregularly serrulate; humeri smooth and strongly developed; disk with broad, shallow basal depressions, and with a distinct, vaguely arcuate lateral carina on each elytron extending from middle to near apex; surface clothed with a few short inconspicuous hairs near apex, very coarsely and irregularly punctate, the punctures coarser and forming more or less distinct rows in basal region along sutural margins, more irregular toward the sides, becoming finer and more obsolete toward the apex, and the intervals smooth.

Abdomen beneath sparsely, irregularly ocellate-punctate, the punctures very shallow, elongate, open posteriorly, and from the center of each arises a very short white hair; intervals obsoletely reticulate; last segment rather narrowly rounded at apex, with the apical groove deep, and following the outline of the apical half of the segment. Metasternum punctured similarly to that of the abdomen. Prosternum finely, densely reticulate.

Length, 3 mm.; width, 1.2 mm.

Type locality.—Las Mercedes, Costa Rica.

Type.—Cat. No. 41613, U.S.N.M.

Described from a single specimen collected on bushes at the type locality, November 15, 1922, by Ferd. Nevermann. Las Mercedes is on the northern slope of the volcano Turrialba, at an altitude of 150 meters, in the Santa Clara district.

In Doctor Obenberger's paper on a Revision of the Genus Taphrocerus,[1] this species runs down to *laesicollis* Chevrolat in his table to the species, but there seems to be an error in the placing of *laesicollis* in the table. Doctor Obenberger places it among the species having the elytral carinae distinct only in the apical region, whereas they are distinct only in the humeral region. Chevrolat,[2] in the original description of this species from Cuba, describes the elytra as having the "callo humerali elevato costulam longitudinalem efficienti." *Taphrocerus brevicarinatus* is also allied to *depilis* described by Kerremans from Brazil, but that species is shining black above, with

[1] Sbornik, vol. 2, 1924, p. 48. [2] Ann. Soc. Ent. France, ser. 4, vol. 7, 1867, p. 587.

a feeble bronzy green reflection, and the elytra are sparsely clothed with more or less distinct whitish hairs.

BRACHYS NEVERMANNI, new species

Male.—Broadly cuneiform, more than twice as long as wide, broadly rounded in front, more acuminate posteriorly, moderately shining, and sparsely pubescent, the pubescence forming more or less distinct designs on the elytra; above dark brown, with more or less distinct aeneous and greenish reflections in certain lights; beneath piceous, with a feeble aeneous tinge.

Head feebly convex, strongly flattened in front, and without gibbosities on the vertex, but with a narrow longitudinal groove on the front, the groove becoming obsolete on the occiput and behind the epistoma; surface finely, sparsely punctate or granulose on occiput and vertex, with a smooth area on each side of the front, densely, finely punctate on lower half, sparsely clothed with recumbent yellowish hairs on occiput and vertex, and densely clothed with long, semierect silvery white hairs behind the epistoma; epistoma very narrow between the antennal cavities, slightly elevated, and not transversely carinate in front.

Pronotum moderately convex, nearly two and one-half times as wide as long at middle, distinctly narrower at apex than base, and widest at base; sides obliquely narrowed from base to apical angles; when viewed from the side the lateral margins are feebly sinuate, and more strongly arcuate near the posterior angles for the reception of the anterior legs; anterior margin transversely truncate; base transversely truncate to middle of each elytron, where it is feebly arcuately emarginate, then turning obliquely backward to the scutellum, in front of which it is feebly arcuately emarginate; posterior angles rectangular; disk broadly, transversely concave on basal half, the concavity extending obliquely forward to the apical angles, causing the antero-median part of the disk to be regularly convex, and with an elongate elevation and a distinct short carina on each side near the posterior angles; surface densely, obsoletely reticulate, and sparsely, irregularly punctate, the punctures fine and very sparse on convex area, but becoming ocellate-punctate in the depressions, and sparsely, irregularly clothed with rather long, recumbent yellow hairs, with a few white hairs near the apical angles. Scutellum triangular, vaguely wider than long, with the anterior margin feebly rounded, and the surface densely, obsoletely reticulate.

Elytra slightly narrower than pronotum at base; humeral angles obtusely rounded; sides nearly parallel to middle (feebly arcuately emarginate at basal fourth), then obliquely narrowed to the tips, which are separately narrowly rounded, with the lateral margins

entire; disk with distinct lateral carinae, which are sinuate, strongly elevated, and extending from humeral angles to near the apex, a broad, deep depression on each side behind the humeral angles, and with broad, moderately deep, transverse basal depressions; surface finely, sparsely, irregularly punctate, with a few coarser punctures forming more or less distinct rows in basal region, the intervals alutaceous, and each elytron ornamented with pubescent designs as follows: A single row of brownish yellow hairs extending from basal lobe to near middle, a shorter row between it and the humerus, a broad, irregular fascia at middle, composed of sparsely placed pale yellow and brownish yellow hairs intermixed, with a few small indistinct spots of white hairs anteriorly, a similar fascia covering the apical fourth, with a more distinct white pubescent spot anteriorly near sutural margin, a few scattered hairs of the same color in the humeral region, and between the median and apical fasciae the surface is sparsely clothed with inconspicuous, semierect dark brown hairs.

Abdomen beneath sparsely ocellate-punctate, the punctures large, distinct, oblong, open posteriorly, and from each puncture arises a long, recumbent white hair; intervals densely, obsoletely reticulate; last segment broadly, obtusely rounded at apex, with the margin entire, and the apical groove deep and following the outline of the posterior margin.

Length, 3 mm.; width, 1.25 mm.

Type locality.—Hamburg farm, Costa Rica.

Type.—Cat. No. 41614, U.S.N.M.

Described from a unique male collected on an unknown bush at the type locality, December 15, 1824, by Ferd. Nevermann.

This species resembles *ornatus* Fisher, but in that species the front of the head is not densely clothed with long silvery white pubescence, the surface above is piceous and more strongly shining, and the white pubescence on the elytra forms distinct designs, whereas in *nevermanni* it simply forms a few inconspicuous spots.

U. S. GOVERNMENT PRINTING OFFICE: 1929

BRIAROSACCUS CALLOSUS, A NEW GENUS AND NEW SPECIES OF A RHIZOCEPHALAN PARASITE OF LITHODES AGASSIZII SMITH

By H. Boschma

Of the University in Leiden, Holland

The collection of the United States National Museum contains among a large number of other specimens, which for the greater part are representatives of previously described genera, one that is remarkable for its enormous size. It is a parasite of *Lithodes agassizii* Smith, which has been taken from its host. Consequently its position on the host is unknown, but probably the long axis of the parasite was lying in the transverse plane of the host, as in this manner more space is available between the thorax and the abdomen of *Lithodes.*

The internal anatomy of the parasite is very similar to that of *Peltogaster,* and the parasite certainly is a representative of the Peltogastridae. In some respects, however, the specimen differs from *Peltogaster* and the other known genera of the family, and these differences are striking enough to establish for this specimen a new genus, which I propose to call *Briarosaccus* on account of the gigantic size of the type specimen. This genus may be defined as follows:

BRIAROSACCUS, new genus

Body slightly elongate, curved. Stalk about in the central part of the dorsal surface. Mantle opening at one extremity. Mesentery from the mantle opening to the posterior part of the dorsal surface, thin, except in the region of the stalk. Colleteric glands at the left and right side of the mesentery, highly lobular. Testes paired, situated in the dorsal part of the visceral mass, parallel to long axis.

In general structure *Briarosaccus* reminds one strongly of that of *Peltogaster,* from which it differs chiefly in the relative narrowness of the mesentery, the more complicated structure of the colleteric glands, and in its peculiar retinacula. The mesentery which joins the mantle to the visceral mass in *Peltogaster* is very broad (Boschma, 1928, fig. 4), having the breadth of one-fourth or more of the surface of the latter. Consequently it can not be compared directly with that in the Sacculinidae, in which there is a narrow ligament connect-

ing the visceral mass with the mantle. In *Briarosaccus* the mesentery is comparatively narrow as in the Sacculinidae (fig. 3).

The type specimen of the genus, described below, may be characterized as a distinct species especially by the structure of the chitinous covering of the mantle.

BRIAROSACCUS CALLOSUS, new species

Type.—Cat. No. 62304, U.S.N.M., on *Lithodes agassizii* Smith, "Albatross" Sta. 2666 (off Fernandina, Fla., 270 fathoms) or Sta. 2677 (off Cape Fear, N. C., 478 fathoms), 1886.

External cuticle thick and callous, with grooves and shallow pits. The surface is covered with small excrescences, which have a length of approximately 9μ and form a dense covering of the outer layer.

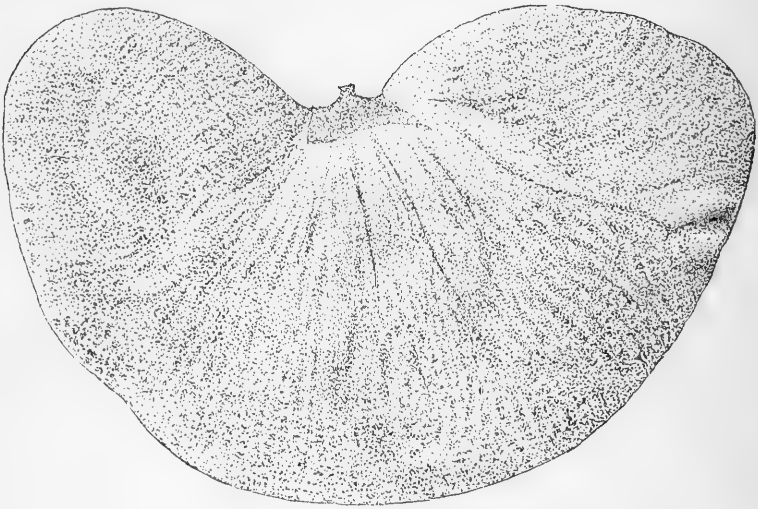

FIGURE 1.—BRIAROSACCUS CALLOSUS, RIGHT SURFACE. NATURAL SIZE

Internal cuticle with retinacula of large size, containing numerous spindles, which vary in length from 15μ to 55μ.

The specimen has a length of 98 mm, its height attains 53 mm, and the thickness amounts to 31 mm. As compared with all other Rhizocephala hitherto known it really is a gigantic animal (fig. 1). The thick external cuticle possesses a number of grooves which spread from the stalk toward the ventral region of the parasite. Between these grooves and especially at the ventral region the surface of the mantle shows numerous small depressions, giving the surface a dotted appearance. The stalk is surrounded by a strong shield, consisting of chitin of a harder kind and of a darker color than the remainder of the external cuticle. The mantle opening is found at one side of the animal, which consequently has to be regarded as the anterior pole. In Figure 1 it is visible, though rather indistinctly,

at the extreme right of the figure. It is surrounded by a thick sphincter, as a result of which the parts around the mantle opening slightly protrude, forming thereby a kind of wall. The shape of the mantle opening is more distinctly visible in Figure 2, which represents a part of the anterior region of the animal.

FIGURE 2.—BRIAROSACCUS CALLOSUS, PART OF THE MANTLE, WITH THE MANTLE OPENING. APPROXIMATELY NATURAL SIZE

For the study of the internal structure the mantle has been removed from the visceral mass. Figure 3 shows the greater part of the internal surface of the mantle. At the left side of the figure the mantle opening, surrounded by its strongly developed sphincter, may be seen. Slightly above the center of the figure the region of the stalk is to be seen as a concavity in a part of the mesentery. The latter, which has been detached from the visceral mass, extends from the sphincter of the mantle opening to the posterior part of the dorsal surface (behind the stalk). Only a part of the mesentery, the posterior part, is found exactly at the dorsal surface; the anterior

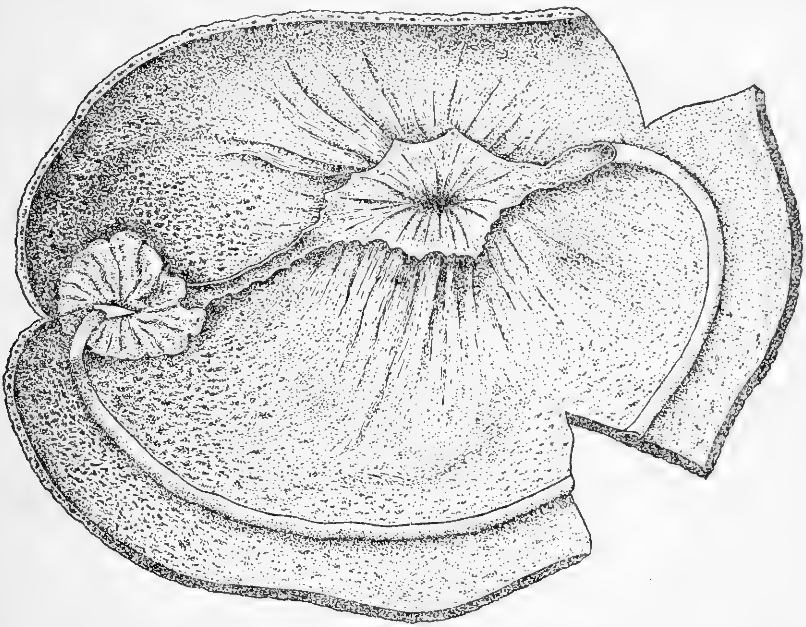

FIGURE 3.—BRIAROSACCUS CALLOSUS, THE GREATER PART OF THE MANTLE, INTERNAL SURFACE

part of the mesentery stretches from the mantle opening along the right surface of the mantle toward the stalk. The mantle opening

also does not occupy exactly the anterior pole, but lies slightly on the right side of the median plane. Consequently the parasite is not completely bilaterally symmetrical. Except the central part of the mesentery, which surrounds the stalk, the whole of this organ

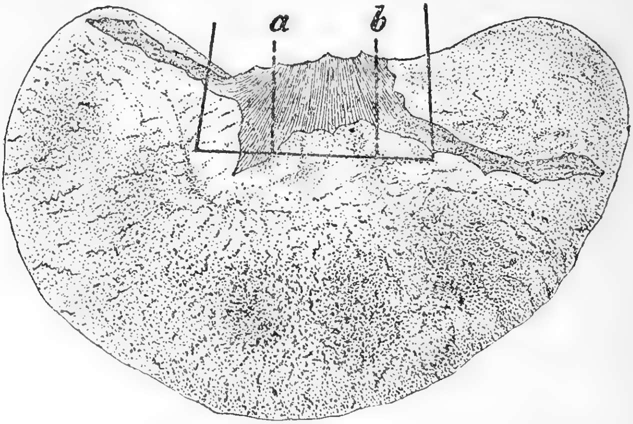

FIGURE 4.—BRIAROSACCUS CALLOSUS, VISCERAL MASS, RIGHT SURFACE. THE SOLID LINE DELIMITS THE PART FROM WHICH SECTIONS HAVE BEEN MADE, THE LINE *a* LOCATES FIGURE 6, AND *b*, FIGURE 5

constitutes a narrow strip of tissue connecting the visceral mass with the mantle. The central part is much broader; here a quantity of strong muscles are present which fasten the visceral mass to the shieldlike portion of the cuticle round the stalk. As in other Rhizo-

FIGURE 5.—BRIAROSACCUS CALLOSUS, PART OF A TRANSVERSE SECTION *b* IN FIGURE 4, SHOWING THE TESTES. × 7

cephala, the mesentery contains large lacunae, one of which is in connection with a spacious lacuna found in the posterior region and in the median plane of the ventral surface of the mantle. In the anterior region this lacuna terminates in the sphincter of the mantle

opening. This lacuna is distinctly visible in Figure 3; it denotes approximately the ventral and posterior border of the mantle when not spread out as in the figure.

Nearly the whole space of the mantle cavity was occupied by the well-developed visceral mass, no eggs or developing larvae being present in the mantle cavity. The visceral mass (fig. 4) possesses a somewhat wrinkled surface, doubtless on account of the pressure of the irregular internal surface of the mantle. The scar of the removed mesentery is visible in the figure, at the left side the posterior part, which lies approximately in the median plane; at the right side of the figure the anterior part of the mesentery, which deviates from the median plane and runs along the right side of the visceral mass toward the mantle opening, is to be seen.

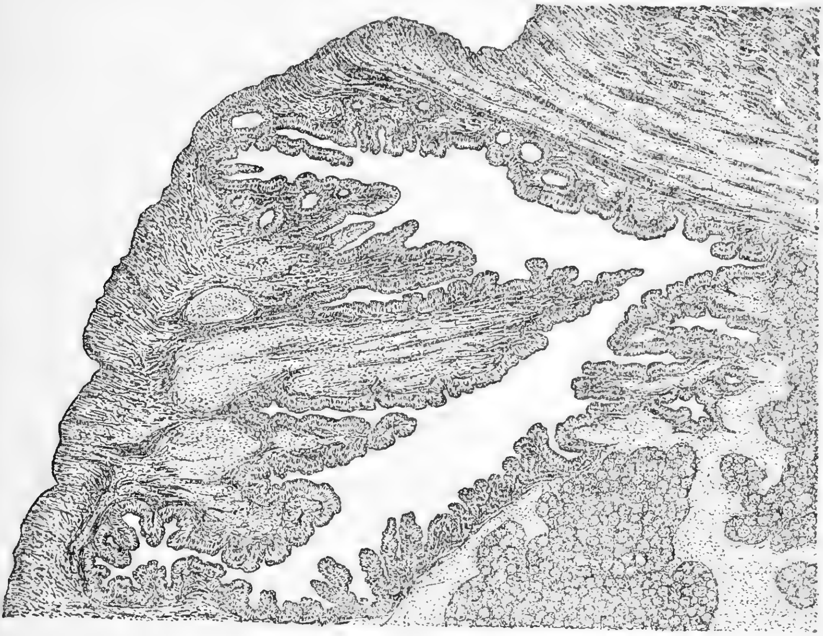

FIGURE 6.—BRIAROSACCUS CALLOSUS, PART OF A TRANSVERSE SECTION *a* IN FIGURE 4, SHOWING ONE OF THE COLLETERIC GLANDS. THE CONTENTS OF THIS GLAND HAVE BEEN OMITTED IN THE FIGURE. × 14

For the study of the internal organs a part of the visceral mass has been cut off. This part, from which a series of sections has been made, is indicated in Figure 4 by the full line. Parts of two sections are represented in the present paper; Figure 6 is a drawing of a part of a section corresponding with the line *a* in Figure 4, whilst Figure 5 is drawn after a section from the region indicated with *b* in Figure 4.

With the exception of the part surrounded by the line in Figure 4, the visceral mass consists nearly completely of groups of eggs in the ovary; between these groups of eggs numerous smaller and larger muscles are present. As already remarked, the central part of the

dorsal region is highly muscular (fig. 5); moreover, in this part large lacunae are found which are connected with the one which runs along the ventral surface of the mantle.

The testes (fig. 5) are found in the dorsal part of the visceral mass, in the region below the stalk. They consist of more or less straight tubes which are directed parallel to the median plane: Surrounding the testes there are lacunae of rather large size. The male genital openings could not be found in the sections, as the posterior part of the testes is rather indistinctly visible. In common with all other organs, the testes have a comparatively large size; their diameter amounts to 1 mm approximately in some parts.

The colleteric glands have a much more complicated structure than those of the other Peltogastridae. They are at each side of the median plane, not far from the stalk; their larger diameter amounts to 10 mm approximately. The lumen of the glands is rather wide, projecting from the center outward as a number of diverticules which in turn give rise to smaller divisions toward the periphery of the gland (fig. 6). The epithelium of these glands consists of a double layer of rather high cells, which are surrounded externally by a thin muscular layer. At various points the latter is connected with the muscles which traverse the visceral mass. The colleteric glands contain a rather irregular mass of secretion (for the sake of clearness omitted in the figure) in which no distinct structure can be found. An opening of the glands on the periphery of the visceral mass could not be detected, but at the proximal side of the glands there is a large opening, constituting the passage for the ripe eggs into the glands. By their highly complicated structure the colleteric glands of *Briarosaccus* form one of the generic peculiarities separating the genus from the other Peltogastridae.

The specific characters of *Briarosaccus callosus* may be derived with sufficient accuracy from the details of the chitinous coverings of the external and internal surface of the mantle. As might be expected, these parts also are characterized by their thickness and solidity.

The external cuticle of the mantle (fig. 7*a*) consists of two layers, owing to the fact that the cuticle is in the process of ecdysis. One might think that the two layers had developed by fission of the originally simple external cuticle, but as both of the two layers at their upper surface possess the characteristic small excrescences described below, we have here a formation of a new layer under the old external cuticle. These two layers of the cuticle, both with their characteristic excrescences, have been found in different Sacculinidae (Boschma, 1927); and the phenomenon, therefore, is not at all uncommon among Rhizocephala. Both of the layers of the external cuticle possess at their upper surface numerous small slender papillae (fig. 7*b*), which have a length of about 9μ. Those of the outer layer are

somewhat less regular by being partially worn off, but on the whole they have the same form and size.

The two layers of the external cuticle have approximately the same thickness, which in the lateral parts of the mantle is about 275μ. With a number of folds and irregular excrescences the two cuticular layers project into the mantle, causing thereby the wrinkled appearance of the whole animal.

The mantle is highly muscular; in transverse sections a number of muscular elements are visible, which constitute the transverse musculature of the mantle. Moreover, many of the epithelial muscular cells connect the external and the internal cuticle. Besides the

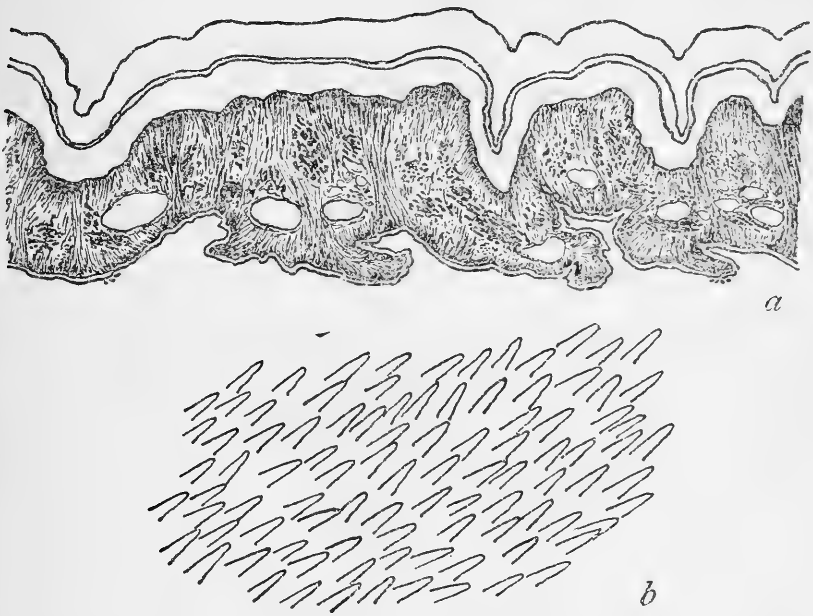

FIGURE 7.—BRIAROSACCUS CALLOSUS. *a*, SECTION THROUGH THE MANTLE, SHOWING THE TWO LAYERS OF THE EXTERNAL CUTICLE, THE INTERNAL CUTICLE, AND THE EPITHELIUM, MUSCLES, AND LACUNAE OF THE MANTLE. $\times$ 18. *b*, EXCRESCENCES OF THE EXTERNAL CUTICLE, SEEN FROM ABOVE. $\times$ 660

muscles and the epithelium the mantle contains several lacunae of different sizes.

As the external cuticle the internal chitinous sheath of the mantle is strongly developed; it may even attain a thickness of 50μ. Its surface is rather irregular and wrinkled, and bears a large quantity of well-developed retinacula, two of which may be seen in the section represented in Figure 7*a*. The retinacula of *Briarosaccus* (fig. 8) differ from those of *Peltogaster* by their great number of spindles. They occur in abundance on the lower surface of the internal cuticle (fig. 8*a*) and vary in size from 75μ to over 200μ. A few more strongly enlarged retinacula are represented in Figures 8*b*–*d*, from which may be seen the strong variability in the shape of these organs and of their spindles. Not only the number of spindles in each retinaculum is different (this

number varies from 10 to 40 approximately) but also the size and shape of the spindles are subject to strong variation. The shape of the spindles strongly suggests those in *Peltogaster*, which have been described by Delage (1886) and figured by the present author (Boschma, 1928, fig. 3). The spindles have a more or less pointed extremity; some are comparatively slender, others are thicker. The length of the spindles, even of those of one retinaculum, varies from 15μ to 55μ. Barbs could not be found at the surface of the spindles, but when studied with a high power their surface appears somewhat

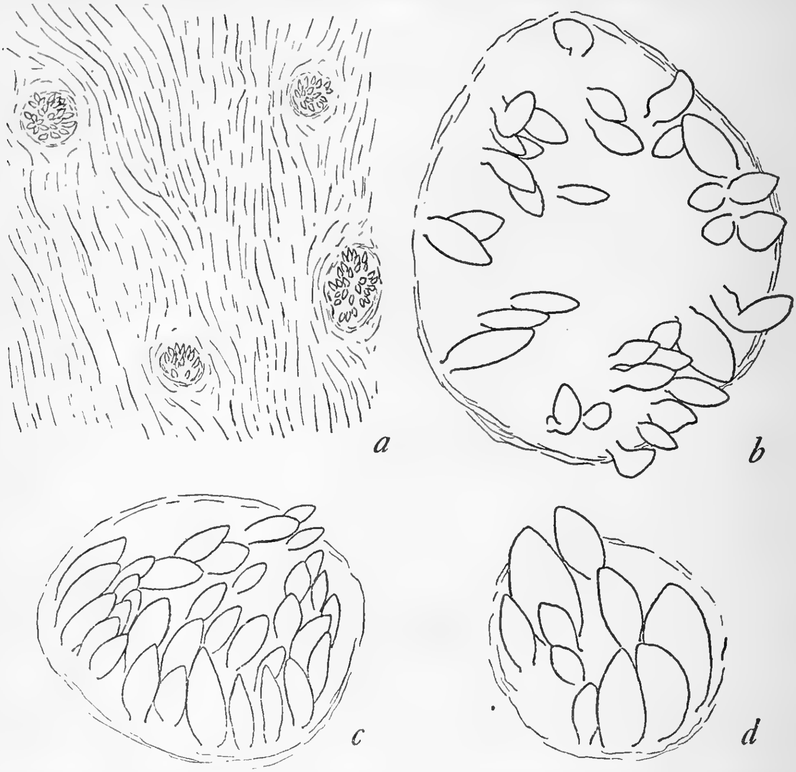

FIGURE 8.—BRIAROSACCUS CALLOSUS, RETINACULA. *a*, PART OF THE INTERNAL CUTICLE WITH RETINACULA. × 45. *b*, *c*, AND *d*, THREE DIFFERENT RETINACULA. × 330

granulated, but without definite excrescences such as occur on the spindles of many Sacculinidae. The basal part of the spindles is more or less narrowed, forming a kind of short stalk.

LITERATURE CITED

H. BOSCHMA, 1927. Über europäische Formen der Gattung *Sacculina*. Zool. Jahrb., Abt. f. Syst., vol. 54.

———, 1928. Rhizocephala of the North Atlantic Region. The Danish Ingolf Expedition, vol. 3, part 10.

Y. DELAGE, 1886. Sur le Système Nerveux et sur quelques autres points de l'Organisation du *Peltogaster* (Rathke). Arch. Zool. Exp. Gén., vol. 4.

U. S. GOVERNMENT PRINTING OFFICE: 1930

A NEW VARIETY OF THE HEXACTINELLID SPONGE, RHABDOCALYPTUS DAWSONI (LAMBE) AND THE SPECIES OF RHABDOCALYPTUS

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The sponge herein described was sent to us for identification by the United States Bureau of Fisheries. It was "taken on a halibut hook in 100 fathoms of water off Cape Spencer, Alaska." It is a remarkably fine specimen, falling under *Rhabdocalyptus dawsoni* (Lambe). The differences from the type are for the most part the usual quantitative ones which mark off the members of a widely ranging species that live at some considerable distance from one another. A more definite point of difference is exhibited by the spicules lining the paragastric cavity and this makes it advisable to classify the form as a (presumably geographical) variety.

RHABDOCALYPTUS DAWSONI var. ALASCENSIS, new variety

Diagnosis.—Variety marked off from the type by the autogastralia. These are hexacts with tangential rays, 315μ to 385μ long, minutely spinose; parenchymal ray usually shorter than tangential rays, smooth or feebly spinose; free ray smooth or occasionally feebly spinose, smoother and distinctly shorter than the other rays.

Type-locality.—Off Cape Spencer Alaska.

Holotype.—Cat. No. 21382, U.S.N.M.

Rhabdocalyptus (*Bathydorus*) *dawsoni* was established by L. M. Lambe (1892, p. 73), for four specimens taken in 20–40 fathoms off the coast of British Columbia. F. E. Schulze (1897, p. 37; 1899, p. 54) after examining preparations made from one of Lambe's specimens assigned the form to *Rhabdocalyptus* Schulze (Schulze 1887, p. 155), one of the genera with discoctasters (Lambe's discohexasters, 1892, pl. 6, fig. 2*e*; the spicule often gives the appearance of having only six instead of eight main rays). Schulze further reports (1899, p. 55) on his study of three specimens and some fragments of this species taken by the *Albatross* off the coast

58645—30

of California and British Columbia at depths ranging from 55 to 437 meters. The species is vase-shaped, as are the species in general (*R. plumodigitatus* Kirkpatrick is cup-shaped), of the genus. The largest specimen of *R. dawsoni* hitherto taken is Lambe's type, about 275 mm. high.

The sponge (pl. 1) herein described is a dried vase, widely open above, about 510 mm. high, tapering somewhat toward the upper (cloacal) and lower ends; cross diameter at middle of body about 250 mm.; lower end irregular as if molded over the substratum; extreme lower end only about 55 mm. wide. Wall of vase at middle of body about 22 mm. thick. Rim of cloacal aperture torn away on one side; normal aperture would measure about 130 mm. in diameter. Dried sponge is of a light yellowish color; firm but fragile and very light in weight.

The autodermalia have been lost, washed or rubbed off, from almost the entire surface of the body. The meshes of the hypodermal network are therefore exposed; they are polygonal, something less than 1 mm. in diameter, the intervening strands narrow. Beneath this network the open ends of numerous (doubtless afferent) radial canals are plainly visible. The gastral membrane is well preserved, smooth, showing neat squarish meshes just visible to the eye and distinctly smaller than those of the hypodermal reticulum. Beneath this membrane the open ends of numerous radial (doubtless efferent) canals may be seen as on the outer surface.

The surface of the sponge shows many depressed areas which are apparently mere accidental growth features. Some of them, as being protected places, are lined with, some practically filled with, prostal pentacts. Some of them contain also dense matted tufts of long projecting spicules (prostalia lateralia). These include many slender subcylindrical diacts, in general smooth but roughened subterminally, with rounded ends; characteristic spicules measure 10–17 mm. in length, diameter about 12μ. Other stouter diacts occur, smooth in general but roughened subterminally, tapering gradually from the middle toward the slender ends which terminate in rounded or fairly sharp points; characteristic spicules measured 16–19 mm. in length, diameter at the middle 35μ to 56μ. Schulze records, for the type, the prostalia lateralia as consisting of prostal oxypentacts (hypodermalia, see p. 37) and smooth oxydiacts 10–15 mm. by about 40μ.

The cloacal rim bears a marginal fringe 10–20 mm. high made up of long diacts, smooth in general, roughened subterminally. Spicules resembling the stouter ones described above and as large as 22 mm. by 63μ occur. The slenderer ones, many of which accompany the larger as comitalia, resemble the slender diacts described above. Schulze (1899) finds that the fringe in his specimens of the type is

8–10 mm. high and that the spicules composing it are to be classed as ascending prostalia lateralia.

There is no definite root tuft but there are some matted tangles of long projecting spicules at the lower end of the body resembling in appearance and composition those on the lateral surface. The larger form of diact may reach in these basal tufts a length of 25 mm. diameter at middle 100μ. These spicules commonly taper continuously from the middle toward the ends, but in some spicules the tapering ceases at a little distance from the extremity and the ends are clavate.

The parenchymalia are diacts, stout and slender, strewn in all directions through the parenchyma. There are many bundles of the usual sort consisting of one stout diact (principal) accompanied by slender ones (comitalia). The spicules are like those described above as projecting from the lateral surface and basal end, except that the class of stout oxydiacts includes relatively shorter and stouter spicules grading down to 8–10 mm. by 40μ to 90μ, sometimes with smooth ends. Just below the gastral surface and tangential to it still smaller diacts of this class occur. They may be as small as 1 mm. by 28μ near the middle; the actual middle as in the case of the larger spicules may show bosses representing the vestigial rays; one end of the spicule is occasionally rounded, the other end pointed. An occasional stout hexact is found in the parenchyma; these are probably autogastralia that have passed into the sponge wall during maceration. Typically the parenchymalia in these sponges include no hexacts. In the type Lambe finds the parenchymalia principalia are stout smooth oxydiacts, 11.06 mm. by 100μ. Schulze notes the occurrence of diacts, in general smooth but with roughened ends, 10 mm. long and over. Lambe finds the parenchymalia comitalia are diacts up to 8.8 mm. by 10μ; ends roughened, enlarged and blunt pointed or rounded and club-shaped. The variety and the type evidently agree well enough in these matters. Moreover the parenchymalia exhibit, in details, too much variation within the same individual to afford good points for the distinguishing of species.

The spicules regarded as of importance in the classification of these sponges are the autodermalia, hypodermal pentacts, autogastralia (there are no hypogastralia, paratangential bundles of parenchymal diacts alone underlying the autogastralia, Ijima 1897, p. 47), oxyhexasters and discoctasters.

Autodermalia.—As said, these have been lost over nearly the whole surface. Fortunately they are still present in some small areas close to the cloacal aperture. Both pentact and hexact forms occur. Four-rayed forms (stauracts) were not observed but they may be normally present. The rays are roughened (minutely spinose), blunt-pointed, 60μ to 70μ long. The spicules are similar to those recorded for the

type by Lambe (stauracts and pentacts, rays 60μ long) and Schulze (pentacts, rays 80μ long).

Hypodermal pentacts.—Present as prostalia in large numbers over parts of the dermal surface, projecting several millimeters. Some of the surface depressions are, as said, filled with a tangle of these spicules. Parenchymal ray is smooth, slender and tapering, becoming very slender toward the free end, reaching 6.5 mm. in length. Paratangential rays about 2.4 mm. long; spines 140μ long and shorter, on superior-lateral surfaces of ray. Some of the pentacts actually in the substance of the sponge are somewhat smaller than the prostalia and have spineless paratangential rays. The spicules do not differ essentially from those of the type. Lambe gives the proximal (parenchymal) ray as 8 mm. long, paratangential rays about one-third as long. Schulze records that the prostal pentacts include those with (typical) spined paratangential rays and others with these rays smooth; and that the paratangential rays are sometimes bent over toward one side (paratropal).

In the *autogastralia* the Alaskan sponge differs in a definite detail from the type, even though the specimens assigned to the type would seem to fall in two groups in respect to this point and should therefore, it would seem, be separated in some fashion in the formal classification. Thus Lambe (1892, p. 73; pl. 6, fig. 2*k*) records the autogastralia as oxyhexacts, rays roughened and similar, ray length only about 60μ. In Schulze's specimens these spicules are hexacts in which the tangential and parenchymal rays are about 120μ long and minutely spinose; the free ray longer than the others, up to 300μ long, and more strongly spinose. Schulze (1897, p. 36) does not speak of this difference between his record and that of Lambe and the difference may conceivably be due to Lambe's having examined a specimen in which the actual autogastralia had been largely washed away.

In the autogastralia of the Alaskan sponge (fig. 2) the four tangential rays are strong, minutely and sharply spinose, tapering to points, characteristically about 350μ long and 40μ thick at the base. The length of these rays, measuring from center of spicule, ranges in general from 315μ to 385μ. One of the four is occasionally shorter (250μ) than the others and smooth. Smaller spicules (presumably younger forms) also occur very sparingly; in these the six are about all alike, the ray length in the actual measurements ranging from 210μ to 140μ. The tangential rays of the autogastralia in general are arranged regularly as to make squarish meshes, the side of the mesh approximately equalling in length a spicule ray. The parenchymal ray is usually but not always shorter than the tangential rays of the same spicule, the range in actual measurement being 250μ to 380μ; tapering, pointed, smooth, or feebly spinose. Free ray

typically (that is, nearly always) smooth, although occasionally it is feebly spinose, noticeably shorter than any of the other rays, tapering to a point or sometimes to a rounded point; common range in length 175μ to 220μ, but the ray is occasionally as short as 80μ or as long as 250μ. This ray when exceptionally short does not taper and is terminally rounded or dilated. Thus the autogastralia differs greatly from those recorded by Lambe and in less degree, but yet qualitatively, from those of Schulze's specimens.

There are no hypogastralia. And yet in radial sections we have seen inequiended, diacts, five or six in a section 10 mm. wide, arranged radially to the gastral surface as the parenchymal rays of the hypodermal pentacts are arranged radially to the dermal surface. The larger end of the diact is directed toward the gastral surface and the axial cross is very much nearer this extremity than it is to the more attenuated parenchymal end, the lengths of the two rays in a typical spicule being as one to three. These facts give some ground for regarding the inequiended diacts as vestigial hypogastralia. Hypogastral pentacts are absent in most members of this family, the Rossellidae (Schulze 1897, p. 13). The inequiended diacts observed in position were without comitalia; about 2 mm. long, 45μ thick at middle of spicule, tapering toward both ends, minutely spinose at both ends, which were sharp or rounded. In macerations longer spicules of the same kind were observed, the length varying up to 7 mm. At the site of the axial cross there may or may not be conspicuous bosses.

The *oxyhexasters*, varying to the hexactine shape (the intermediate forms being sometimes known as hemioxyhexasters) of the Alaskan sponge agree well enough with those of the type. For the latter (Lambe and Schulze) the diameter is recorded as 60μ to 100μ; principal rays smooth and very short; terminals 2–3, long, smooth, or feebly roughened. The spicules of the Alaskan sponge reach a somewhat larger size, 90μ to 144μ diameter.

The *discoctasters* of the Alaskan sponge are like those of the type. In the latter (Lambe and Schulze) they are set down as having a diameter 60μ to 100μ; the (eight) main rays 20μ long; terminals 6–10 in number and 20μ to 30μ long, moderately divergent, the terminal knob (disk?) very small. The diameter of the spicule in the Alaskan sponge is commonly about 92μ. The strikingly small size and the shape of these spicules are regarded by Schulze (1897, p. 13) as constituting the most important of the species-characters.

The *microdiscohexasters* recorded by Schulze were not observed in the Alaskan sponge. The specimen to be sure was a dried one and these very small spicules may have been lost. On the other hand the parenchymal tissue has been so remarkably preserved

(mummified) near the gastral surface that individual cells and intercellular connections are still plainly recognizable and the spicules should be visible, one would think, if actually present. Schulze (1897, p. 37; 1899, p. 55) observed these spicules both in the *Albatross* specimens and in preparations made from one of Lambe's specimens. He records them as numerous; diameter 20μ to 35μ; terminal rays 8–12, longer than the principals, delicate and knobbed. He notes (1904, p. 35) that these very small and delicate spicules are rare and difficult to observe in some individuals of many *Rhabdocalyptus* species. Ijima (1897, p. 45) thinks they are probably never absent, although rare in some species. Schulze (1904, p. 36) regards their apparent absence, as in the cases of *R. lophodigitatus* (*plumodigitatus*) Kirkpatrick and *R. australis* Topsent, as having no significance for classification.

Ijima in his splendid report (arranged for publication by Yaichiro Okada) on the Siboga hexactinellida lists (1927, p. 377) the known species of *Rhabdocalyptus*, 13 in number. The following brief diagnoses of the species other than *R. dawsoni* will serve to indicate the persistent lines of past variation within this group.

R. tener F. E. Schulze (1899, p. 57), coast of California. Autodermalia, pentacts and hexacts. Autogastralia larger than autodermalia, hexacts with free ray longer and more spinose than the others. Oxyhexasters (varying, as in the other species of the genus, to the hexactine shape, Ijima 1897, p. 45) with spheroidal central thickening; terminal rays exceedingly slender. Discoctasters 80μ to 100μ diameter; the nodal protuberances, representing the six primary rays of the primitive hexact, unusually large and conspicuous. Microdiscohexasters not observed.

R. nodulosus F. E. Schulze (1899, p. 58), coast of California. Autodermalia, stauracts and pentacts. Autogastralia, strong oxyhexacts, free ray usually longer and more spinose than the others. Oxyhexasters with spheroidal central thickening. Discoctasters large, 240μ to 300μ diameter.

R. asper F. E. Schulze (1899, p. 60), coast of California. Autodermalia, pentacts and stauracts. Autogastralia, hexacts and pentacts. Prostal hypodermal pentacts all large; some with tangential rays that measure as much as 1–2 cm. in length and are smooth or with only a rough shagreenlike surface. Oxyhexasters 140μ to 160μ diameter. Discoctasters 150μ to 200μ diameter.

R. mirabilis F. E. Schulze (1899, p. 61), coast of Alaska. Autodermalia for the most part small diacts; some pentacts and stauracts. Autogastralia, oxyhexacts; free ray 500μ long and spinose; other rays 200μ long, roughened. Oxyhexasters about 120μ diameter.

Discocasters 160μ diameter; protuberances representing the six primary rays large; terminal disks of secondary rays comparatively large and usually with six marginal teeth.

R. (*Acanthosaccus*) *tenuis* (F. E. Schulze, 1899, p. 66), coast of California. Autodermalia, pentacts, stauracts, and diacts. Autogastralia, oxyhexacts; free ray 600μ to 800μ long and over, more strongly spinose than the other rays; latter rays 200μ to 300μ long. Oxyhexasters represented only by the (derived) oxyhexact form 150μ to 200μ diameter. Discoctasters 200μ diameter; main rays short, sometimes exceedingly short; terminal rays numerous, long and slender, bearing end disks having 5–6 marginal teeth. (*Acanthosaccus* F. E. Schulze 1899, p. 65, was merged in *Rhabdocalyptus* by Ijima 1904, p. 128.)

R. mollis F. E. Schulze (1887, p. 155; Ijima 1897, p. 50; Ijima 1904, pp. 253–301), Japan. Autodermalia, diacts with a few stauracts and pentacts. Autogastralia, oxyhexacts, rays all similar. Oxyhexasters with rays conspicuously barbed proximally. Discoctasters 130μ to 176μ diameter.

R. capillatus Ijima (1897, p. 51; 1904, pp. 276, 302), Japan. Autodermalia predominantly diacts. Autogastralia predominantly hexacts, rays all similar or free ray twice as long as the others. Oxyhexasters 106μ to 136μ. Discoctasters small, 82μ to 106μ diameter; terminals much longer than the main rays, in a solid bunch and distinctly flaring.

R. victor Ijima (1897, p. 52; 1904, pp. 238, 301), Japan. Height may reach almost 3 feet (859 mm.). Autodermalia, stauracts. Autogastralia, oxyhexacts, rays all similar. Oxyhexasters 180μ to 280μ diameter; principals very short or obsolete. Discoctasters 180μ to 240μ diameter.

R. unguiculatus Ijima (1904, pp. 268, 302), Japan. Autodermalia, diacts with a few stauracts or tauacts (3 rayed forms). Autogastralia, oxyhexacts; free ray much longer than the others, 440μ to 550μ; parenchymal ray 230μ to 300μ; tangentials 275μ to 330μ. Oxyhexasters 130μ to 160μ diameter. Discoctasters 143μ to 190μ diameter; terminals much longer than main rays; end-disks with marginal teeth which are largest and strongest on side that is turned away from axis of the tuft of terminals.

R. plumodigitatus Kirkpatrick (1902, p. 220; syn. *R. lophodigitatus* Kirkpatrick 1901, p. 458), South Africa. Shape, that of a subglobular cup. Autodermalia and autogastralia, diacts 600μ to 1,000μ long. Oxyhexasters 90μ to 100μ diameter. Discoctasters of two forms: large ones, 130μ to 160μ diameter, main ray bearing 6–8 very much longer terminals; small ones, 60μ diameter, with more divergent terminals. Microdiscohexasters not observed.

R. baculifer F. E. Schulze (1904, p. 34), South Africa. Autodermalia, diacts 200μ to 600μ long. Autogastralia, diacts commonly longer than the autodermalia. Oxyhexasters 100μ to 160μ diameter; principal rays very short, often vestigial. Discoctasters 160μ diameter. Schulze regards this species as very close to the preceding. He looks on the presence of only one form of discoctaster as the most important differential.

R. australis Topsent (1901, p. 37; Ijima 1904, p. 237), Antarctic. Autodermalia predominantly diacts but stauracts and pentacts also abundant. Autogastralia, hexacts, all rays similar. Paratangential rays of hypodermal pentacts shagreened (that is, finely tuberculate) and also with spines. Oxyhexasters 140μ to 160μ diameter. Discoctasters 180μ diameter; terminals few, three rarely four. Microdiscohexasters not observed.

R. roeperi F. E. Schulze (1887, p. 158), having hypodermal pentacts with spineless paratangential rays, was transferred by Ijima (1897, p. 55) to *Staurocalyptus* Ijima (1897). Likewise *R. dowlingii* L. M. Lambe (1893, p. 37) from British Columbia was transferred to *Staurocalyptus* by Ijima (1897, p. 53).

It will be seen from this survey that ten of the thirteen known species of the genus occur on the two sides of the North Pacific, the coasts of Alaska, British Columbia, and California on the East, the coast of Japan on the West. The variety here recorded is the only form in which the free ray of the autogastral hexact spicule is known to be smoother and smaller than the other rays, although one would expect to find in *R. asper* (see above) spicules of this kind. The opposite development, leading to a free ray longer and more spinose than the others, has occurred in a number of forms (seven). In a few forms all six rays are similar. In two the hexacts have degenerated to diacts.

REFERENCES

IJIMA, I.

1897. Revision of Hexactinellids with Discoctasters, with Descriptions of Five New Species. Annotationes Zoologicae Japonenses, vol. 1, parts 1 and 2. Tokyo.

1898. The Genera and Species of Rossellidae. Annotationes Zoologicae Japonenses, vol. 2, part 2. Tokyo.

1904. Studies on the Hexactinellida. Contribution IV. Rossellidae. (Important for the genera.) The Journal of the College of Science, Imperial University of Tokyo, vol. 18, article 7. Tokyo.

1927. The Hexactinellida of the Siboga Expedition. Siboga-Expeditie, Monographe VI. Brill, Leiden.

KIRKPATRICK, R.

1901. Description of a new Hexactinellid Sponge from S. Africa. Annals and Magazine of Natural History, ser. 7, vol. 7. London.

1902. Descriptions of South African Sponges. Marine Investigations in South Africa. Department of Agriculture. Cape of Good Hope. Capetown.

LAMBE, L. M.
1892. On Some Sponges from the Pacific Coast of Canada and Behring Sea. Transactions Royal Society of Canada for the year 1892. Section IV. Ottawa.
1893. Sponges from the Pacific Coast of Canada. Transactions Royal Society of Canada for the year 1893. Section IV. Ottawa.

SCHULZE, F. E.
1887. Report on the Scientific Results of the Voyage of H. M. S. *Challenger*. Zoology, vol. 21, Report on the Hexactinellida. Edinburgh.
1897. Revision des Systemes der Asconematiden und Rosselliden. Sitzungsberichte der königlich preussischen Akademie der Wissenschaften zu Berlin, vol. 26.
1899. Amerikanische Hexactinelliden. Fischer, Jena.
1904. Hexactinellida. Wissenschaftliche Ergebnisse der deutschen Tiefsee-Expedition, vol. 4, Fischer, Jena.

TOPSENT, E.
1901. Spongiaires. Expédition Antarctique Belge. Résultats du Voyage du S. Y. *Belgica*. Anvers.

EXPLANATION OF PLATES

PLATE 1

The sponge, from the side; actual height about 510 mm.

PLATE 2

FIGURE 1. The sponge from above, × about one-third.
2. Gastral membrane showing the autogastralia in place, the tangential rays of the latter forming a reticulum with, in general, squarish meshes. Photograph × 47.

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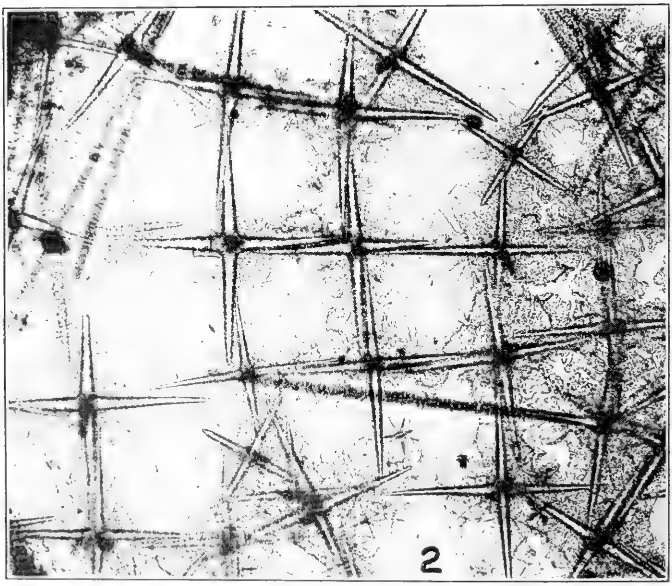
A New Variety of Sponge

For explanation of plate see page 9



A NEW VARIETY OF SPONGE

FOR EXPLANATION OF PLATE SEE PAGE 9

NEW LOWER AND MIDDLE CAMBRIAN CRUSTACEA

By Charles E. Resser
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INTRODUCTION

Among the numerous Cambrian fossils that have been accumulating in the United States National Museum during the last 15 years, there are many undescribed species and some of the specimens are remarkable for the preservation of thin tests or of soft body parts. In order to stimulate further search for the rarer fossils, and particularly for preservations of the softer parts of animals or of delicate plant tissues, it is planned to publish more or less related groups of these animals from time to time. Accordingly, in this paper I have assembled a group of species that centers mainly around the previously described genus *Tuzoia*, but which also includes several unrelated forms that were secured from the same localities as the others. This paper thus adds several new species preserving more than ordinarily thin tests of crustacea and a few with the still softer fleshy parts. Some are from the well known Burgess shale that has already furnished so many interesting animals and plants, but other formations, some of which have not previously been known to yield such fossils, are also represented.

This paper also contains information of interest aside from that naturally attaching to any description of the softer parts of such ancient animals, by presenting certain important stratigraphic facts in addition to further data regarding the geographic distribution and origin of the faunas to which these species belong.

Acknowledgment.—In the preparation of this paper I was kindly assisted by Dr. E. O. Ulrich in the matter of specific determinations as well as by much appreciated general criticism.

The Pennsylvania specimens of *Tuzoia* all belong to the Getz Collection in the Peabody Museum, Yale University. I was permitted to describe the two species represented, through the extreme kindness of Dr. Carl O. Dunbar, who had previously planned to describe them himself.

GEOGRAPHICAL DISTRIBUTION

The fossils described in this paper were secured from five general localities at four widely separated places in North America and Asia. For greater convenience and to prevent numerous repetitions precise descriptions of the several localities are grouped together in the following paragraphs:

List of localities

35k.—Middle Cambrian, Burgess shale: On west slope of the ridge between Mount Field and Wapta Peak, 1 mile northeast of Burgess Pass, near Field, British Columbia, Canada.

Well known fauna with numerous specimens of exceptionally preserved fossils of crustacea, annelids, sponges, algae, and many other forms. Characteristic trilobites: *Neolenus*, *Dorypyge*, *Elrathia*, and others.

67g.—Lower Cambrian, Eager formation: Brown and red (weathered) shales, 5 miles northeast of Cranbrook, British Columbia, Canada.

Contains an upper Lower Cambrian Mesonacid fauna, that includes some new elements.

25.—Lower Cambrian: Parkers Quarry, Georgia, Vermont.

Contains typical Mesonacid fauna.

12x.—Lower Cambrian, Kinzers formation: Getz Quarry, 1¾ miles north of Rohrerstown, Pennsylvania.

Contains the Vermont Mesonacid fauna.

12w.—Lower Cambrian, Kinzers formation: ¼ mile west of Fruitville, 3 miles north of Lancaster, Pennsylvania.

Same fauna and bed as 12x.

—Middle Cambrian: Mount Tang-shih-ling, near Yen-tai colliery, Liau-tung, Manchuria, China.

Dorypyge fauna.

—Middle Cambrian: Huo-lien-chai, Liau-tung, Manchuria, China.

Fauna same as preceding.

The specimens from Manchuria were collected at two near-by places by Prof. Riuji Endo, in the course of his field studies in the regions south of Mukden and they form a part of large and excellent collections whose species are now being described by Doctor Endo and myself. Both localities are located along the railway south of Mukden not far from Yen-tai, hence about in the center of Manchuria.

The Burgess shale locality in British Columbia, across the Pacific Ocean from Manchuria, is too well known to require any further discussion of its geographic situation.

The third locality is also in British Columbia, but many miles south of Burgess Pass, between Fort Steele and Cranbrook. This locality was first called to the attention of Dr. C. D. Walcott and some of the fossils were collected by Col. H. Pollen, formerly of Fort Steele.

The fourth group of localities is also separated from the two in British Columbia by the width of a continent. The two Pennsylvania localities are only a few miles apart along the strike and hence may be treated as one. Parkers Quarry in Vermont is another place that has been known for many years having become famous when *Olenellus thompsoni* was described from it. While it has been known for more than thirty years that the Mesonacid fauna was represented in Pennsylvania, it has only been in the last decade that the fauna has become well represented in the collections and the stratigraphic relations of the beds determined.

STRATIGRAPHIC CORRELATIONS

Relatively large collections, some of them brought together by many years of intensive collecting, are on hand from each of the regions described in the locality lists. Accordingly, we may assume with reasonable confidence that the faunas are fairly represented in our present collections. Yet taking the case of the Burgess shale from which the largest collections (over 35,000 specimens) have been obtained, as an example, we find that in spite of the intensive collecting extending over a number of years, new forms are still found by casual visitors to the outcrop. Strange to relate, all the *Tuzoia* specimens, except the holotype, turned up only after two full seasons' work. Keeping this example in mind we can the more readily comprehend the likelihood of finding further material at any of the places and thereby alter somewhat our present opinions of the exact composition of the several faunas.

The marvellous preservation of such a host of species in the Burgess shale gives that fauna a definiteness that is scarcely equaled by any other in the entire geologic column, even though its exact stratigraphic position in the Middle Cambrian may not yet be precisely fixed. The Burgess shale has usually been regarded as the exact equivalent of the *Ogygopsis* shale member of the Stephen formation which like this bed outcrops in only one restricted area—to the south across the Kicking Horse Valley. But a close scrutiny of the apparently identical faunas reveals the fact that many species formerly regarded as common to the two beds are really distinct, thus

creating some doubt as to the exact contemporaneity of these deposits laid down in two areas separated by only 6 miles. This discrepancy may, however, also be explained by a geographic arrangement whereby the one area was enabled to get more constant restocking from the common parent sea. No question, however, remains concerning the relative position of these beds in their respective sections. The Burgess shale definitely underlies the massive, usually unfossiliferous Eldon limestone, which closes the Middle Cambrian sequence at many places in the Canadian Rockies. Fossils have been reported in the Eldon from localities chiefly to the east and north of Field, and until these and the fossils of underlying formations are studied nothing further can be said concerning the age of the Burgess shale. However, with the information now in hand the statement that its position is above the middle of the Middle Cambrian seems undeniable.

At present it is not possible to say exactly what position the soft yellow shales from central Manchuria hold. From the scanty information in hand it would appear that these shales are either interbedded with or directly overlie the oolitic limestones containing *Dorypyge richthofeni*. In either case this bed is succeeded by a nonoolitic limestone containing the Asiatic *Drepanura* fauna, which apparently belongs to the Middle Cambrian and may therefor have been deposited at the same time as the Eldon, while the underlying oolitic and shaly beds, with a *Dorypyge* fauna, are to be correlated with the upper part of the Stephen. At any rate, considering the Manchurian section as now known, as being fairly representative of Middle Cambrian time, this yellow shale would hold a position somewhat above the middle of that division, and hence be in the same relative position as the Stephen formation. Additional data have recently been secured which we hope will throw more light on the problem and possibly clear up some of the uncertainties.

The Cranbrook locality has yielded a most interesting Lower Cambrian fauna that contains some new elements, particularly a new Mesonacid genus, but which in general agrees with what we ordinarily expect in a Lower Cambrian Mesonacid fauna. This same fauna has been collected from red and gray limestones and from sandstones in the vicinity of the Upper Columbia Lake and seems to continue northward into the Dogtooth Mountains, as the equivalent of the lower Mount Whyte fauna, with the possibility that it is also the same as the Hota[1] fauna at Mount Robson. At Cranbrook the relatively soft *Tuzoia* beds, composing the Eager formation,[2] outcrop but poorly and consequently their relative position is not

[1] Walcott, 1913, Smithsonian Misc. Coll., vol. 57, no. 12, p. 338. When this fauna was described the formation was erroneously given as Mahto.

[2] Schofield, S. J, 1922, Canadian Geol. Surv., Bull. 35, p. 12.

definitely indicated, but since the lower part of the Burton formation outcropping nearby apparently contains a fauna of similar age, while the upper portion contains the Middle Cambrian *Albertella* fauna, it becomes apparent that here the upper Mount Whyte, (*Kochiella* fauna),[3] is absent.

The rare Pennsylvania fossils herein described or referred to are all in the Kinzers formation,[4] which has the typical Mesonacid fauna that is comparable with the Eager formation just mentioned. Beside the *Tuzoia*, *Anomalocaris*, and merostome described from this formation in this paper several other unusual fossils have been found, including notably a sponge and a species of some Holothurian possibly belonging to the genus *Peytonia.* Both the eastern and western Mesonacid faunas have now furnished such fossils that clearly show that the Burgess shale fauna was derived from the same ocean.

Several other Lower Cambrian collections from western North America, made in fine grained argillaceous rocks that break with sufficiently large smooth surfaces to preserve them, give us specimens of phyllopods, among which such genera as *Hurdia*, *Hymenocaris*, *Isoyxs*, together with several new ones, are represented or suggested. In eastern Yun-nan, southern China, Mansuy [5] has found several phyllopods in the *Redlichia* beds, quite similar to those from the western American Mesonacis bearing beds, and in addition a merostome that he described as *Amiella prisca.* Thus it will be seen that many of the "lower" crustacea as well as algae, sponges, jellyfish, and worms were already important in the Lower Cambrian seas, and if we should ever be so fortunate as to find another Burgess shale preservation in these older rocks we may expect a great array of organisms. It will also be observed that indications point to the direct descent of the Burgess shale fauna from these older Mesonacid assemblages. It might be added that certain trilobites in the Eager beds seem to belong somewhere between the Mesonacidae and such Middle Cambrian forms as *Zacanthoides.*

All the faunas here discussed, both the Lower and Middle Cambrian, lived in epicontinental seas whose waters were apparently extensions of the Arctic Ocean.

BIOLOGICAL RELATIONS OF THE FOSSILS

Knowing very little about the structure and systematic relations of the crustacea, I hesitate to say anything in this connection regarding the biological significance or relationships of the fossils presented in this paper, but a few general observations may be in order.

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[3] Walcott, 1917, Smithsonian Misc. Coll., vol. 67, no. 3, p. 63. The Mount Whyte has a Mesonacid fauna in its lower part and the zone with *Olenopsis* (=*Kochiella*) *agnesensis* in the upper.

[4] Stose and Jonas, 1922, Journ. Washington Acad. Sci., vol. 12, no. 15, p. 359.

[5] Mansuy, 1912, Mem. Serv. Geol. L'Indochine, vol. 1, fasc. 2.

Tuzoia when first described was referred to the Leptostraca, and subsequent studies have confirmed this position.[6]

Henriksen (p. 11) suggests that *Anomalocaris* belongs to the same group and that it may be the body of *Tuzoia* or *Carnarvonia*. Walcott[7] associated several phyllopod carapaces, which have since been referred to *Hymenocaris* and *Isoxys*, with *Anomalocaris* prior to the discovery of the numerous entire specimens of *Hymenocaris* in the Burgess shale. In support of Henriksen's idea that *Anomalocaris* may be the body of *Tuzoia* it may be stated that three of the four localities yielding *Tuzoia* have thus far also furnished *Anomalocaris* and that the latter has been found independently only on Mount Stephen.

Genus TUZOIA Walcott, 1912

Tuzoia WALCOTT, 1912, Smithsonian Misc. Coll., vol. 57, no. 6, p. 187.
Tuzoia HENRIKSEN, 1928, Vidensk. Medd. fra Dansk naturh. Fören., vol. 86, p. 16.

Large phyllopod with carapace consisting of two convex valve-like portions. Shell thin, and lateral portions semi-oval, narrowed anteriorly, probably curved evenly downward from the dorsal line; each valve increasing in convexity from the edges toward the keel that extends almost the full length of the shell in an approximately central position; posterior margin usually has several large spines; smaller spines may edge all but the extreme anterior portion of the margin; strong spines along the dorsal line in many species; also on the central keel in some species, sometimes their broad bases unite to form a scalloped frill. Surface usually reticulate; the meshes on the keel and near the dorsal line usually smaller and more crowded than on other parts of the shell. No external eyes or muscle scars observed.

Comparisons.—Comparing *Tuzoia* with *Protocaris* we notice that the shape of the valves, their relative size and the presence of a keel make the two forms look much alike. However, *Protocaris* lacks the reticulations and marginal spines which are persistent features of *Tuzoia* and thus offers an easily applied means of distinguishing them. If *Anomalocaris* is actually the abdominal portion of *Tuzoia* considerable differences of body structure exist. Both specimens of *Protocaris* thus far obtained retain the soft body, whereas none of the numerous *Tuzoia* specimens do, which in itself points to a difference of structure.

Attitude of valves in burial.—Some of the specimens were entombed in such a position that both valves were flattened together

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[6] Henriksen, Critical Notes upon Some Cambrian Arthropods. Vidensk. Medd. fra Dansk naturh. Fören., vol. 86, 1928, p. 15.

[7] Mount Stephen Rocks and Fossils. Canadian Alpine Journ., vol. 1, no. 2, 1908, p. 2.

laterally. In these cases the original convexity of the valvelike portions of the carapace was reduced to almost paper thickness, the originally high keel being more or less displaced from the normal with attendant crowding together of the more dorsal and ventral portions of the thin shell. In many other instances the two valves were buried in more or less normal vertical position that resulted in the two valves being pressed flat dorso-ventrally so that the dorsal line traverses the middle of the fossil and the circumference or periphery represents the original convexity of the conjoined valves. In such cases, moreover, the normally converging ventral portions beyond the keel were folded back underneath the diverging dorsal halves of the valves. In such dorso-ventrally compressed specimens the periphery usually is made by the serrated keel.

Genotype.—*Tuzoia retifera* Walcott, 1912.

Stratigraphic range.—Lower and Middle Cambrian.

Geographic distribution.—Middle Cambrian in Manchuria and British Columbia. Lower Cambrian, British Columbia, and Pennsylvania.

TUZOIA RETIFERA Walcott

Plate 1, figures 1, 2; Plate 4, figure 3

Tuzoia retifera WALCOTT, 1912, Smithsonian Misc. Coll., vol. 57, no. 6, p. 187, pl. 33, fig. 2.

When Walcott first described this species in 1912 in the fourth preliminary paper based on the 1910 and 1911 collections from the Burgess shale quarry, he still had only the single specimen illustrated. Subsequently, among more than a score of additional specimens that appeared, some preserving the margins, certain ones apparently represent this species and consequently a more complete description may now be drawn. After careful scrutiny of the specimens that have marginal spines and of the original type I have come to the conclusion that in the latter the marginal spines have been broken away and that it was not originally without them.

The original description of the species relies exclusively on the illustrations to present the characters of the animal. A formal description even now will add nothing to what can be ascertained from the present illustrations, particularly when these are studied in conjunction with the foregoing generic outline. Several characters may be emphasized by being specifically pointed out here. First, the three posterior marginal spines, the central one in direct line with the keel, may be noted. One or two smaller spines occur forward of these. Along the margin, between both sets small spines or crenulations mark the edge. None of the specimens available permit a definite determination of the presence or absence of spines along the dorsal line where we usually find them in other species.

Whether the imperfect specimen illustrated on Plate 4, Figure 3, really should be regarded as belonging to this species can not be decided with certainty because of its incompleteness, but a careful study of it indicates that it likely does.

Horizon and locality.—Middle Cambrian, Burgess shale; (loc. 35k) near field, British Columbia.

TUZOIA BURGESSENSIS, new species

Plate 2, figure 1; Plate 3, figure 1

Comparing this species with *T. retifera* we first note that it is longer and narrower and that the reticulations of the keel appear to be more numerous and stronger. The posterior marginal spines are about the same in both species but the small spines are larger and more regular both in size and spacing than in the genotype. Those of intermediate size appear to be absent. This species also has several blunt spines along the dorsal line the extensions of which are not as long or slender as in *T. retifera.*

Horizon and locality.—Middle Cambrian, Burgess shale; (loc. 35k) near Field, British Columbia.

Holotype and paratype.—Cat. No. 80477, U.S.N.M.

TUZOIA CANADENSIS, new species

Plate 2, figures 2, 3

This second new species determinable in the Burgess shale material on hand is represented by only three or four fragmentary specimens, yet its specific characters may readily be seen.

Since the general shape and character of the reticulations of this species do not differ materially from the same features in both of the foregoing species its right to specific rank rests on others. The most prominent of these is the possession of four instead of three posterior spines which are longer and slenderer than in the preceding species and they are followed anteriorly by perhaps twelve or more of intermediate size, widely and evenly spaced along the margin, ending with one situated forward of the keel. Between these large and intermediate spines the usual small ones occur, in this case being most like those in *T. retifera.* The spines along the dorsal line are also longer and more slender, and perhaps more numerous than in *T. burgessensis.*

Horizon and locality.—Middle Cambrian, Burgess shale; (loc. 35k) near Field, British Columbia.

Holotype and paratype.—Cat. No. 80478, U.S.N.M.

TUZOIA MANCHURIENSIS Resser and Endo [8]

Plate 3, figures 2, 3

Several rare, fragmentary valves collected at two localities in central Manchuria, constitute the material on which this species is founded. It is quite possible that they represent more than one species. Comparing the Manchurian species with those from the Burgess shale we note that in general shape it differs little from the genotype, but due to the fact that all the specimens preserve only the anterior portions of the valves nothing can be determined regarding the number and characters of the marginal spines. The reticulations are quite similar also, the smaller ones on the keel perhaps being more suddenly differentiated from those on the remainder of the test than usually occurs in the American species. It is the appearance of the keel in the two specimens illustrated that injects some uncertainty as to their specific identity, and this can only be cleared up by securing more material.

Horizon and locality.—Middle Cambrian; Huo-lien-chai and Mt. Tang-shih-ling, near Yen-tai, Manchuria.

Holotype and paratype.—Cat. Nos. 80481, 80482, U.S.N.M.

TUZOIA POLLENI, new species

Plate 5, figures 1–3

This fine Lower Cambrian species is represented in the collections by four practically complete specimens besides a few instructive fragments.

In shape and general appearance it is most like the Middle Cambrian genotype. It differs in its stronger reticulations, more particularly in its four instead of three large posterior spines—in which respect it is like *T. canadensis*—and most of all in the size and abundance of the spines along the dorsal line where five or more may be counted in the anterior half of the line. These spines were considerably longer than indicated in the illustrations, if the small fragment in the collections is properly interpreted as to species and position in the test. None of the specimens clearly preserve dorsal spines in the posterior third or more of the line, and since other species also lack spines in that place it may be assumed that if any were present in this species they were smaller than the anterior ones.

The specific name is given in honor of the discoverer of these interesting fossils in the Lower Cambrian of British Columbia.

Horizon and locality.—Lower Cambrian, Eager formation; (loc. 67g), near Cranbrook, British Columbia.

Holotype and paratypes.—Cat. No. 80485, U.S.N.M.

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[8] This species is here described in collaboration with Dr. R. Endo, and will be cited as *Tuzoia manchuriensis* Resser and Endo.

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TUZOIA NODOSA, new species

Plate 5, figure 4

A second species based on one small complete valve must be established from the Lower Cambrian Cranbrook material.

It is readily distinguished from other species by the large and numerous spines along the dorsal line and by its great width which exceeds any other species. It has four posterior marginal spines like *T. polleni*, but the remainder of the margin seems to be smoother. It also has short blunt spines on the keel.

Horizon and locality.—Lower Cambrian, Eager formation; (loc. 67g), near Cranbrook, British Columbia.

Holotype.—Cat. No. 80486, U.S.N.M.

TUZOIA SPINOSA, new species

Plate 6, figure 4

Another species appears to be represented by two fragmentary valves in the red weathered shales of the Eager formation from Cranbrook. At first, owing to the large spines on the keel, it was thought that the specimens belonged to *T. undosa*, but a more careful comparison indicates that the differences first observed in the marginal spines actually exist and are not merely a matter of preservation. These spines are arranged in two sets, one a widely and irregularly spaced large set between which a smaller more even set occurs.

Horizon and locality.—Lower Cambrian, Eager formation; (loc. 67g), near Cranbrook, British Columbia.

Holotype.—Cat. No. 80489, U.S.N.M.

TUZOIA PRAEMORSA, new species

Plate 6, figure 3; Plate 7, figure 2

Two fine Burgess shale specimens were first regarded as representing a new genus before the manner of folding under compression and the fact that the keel is sometimes spinose were determined. The plate descriptions indicate the manner of folding in both specimens.

This species can not be confused with any other in the Burgess shale because of its scalloped frill on the keel and the marginal spines. It is much more like *T. getzi* from the Lower Cambrian.

Horizon and locality.—Middle Cambrian, Burgess shale; (loc. 35k) near Field, British Columbia.

Holotype and paratype.—Cat. No. 80488, U.S.N.M.

TUZOIA GETZI, new species

Plate 7, figure 3

Several specimens have been secured from the Lower Cambrian in southeastern Pennsylvania and two of them represent another species

of *Tuzoia* that at first sight recalls the Middle Cambrian *T. praemorsa* and the Lower Cambrian *T. spinosa.* It can not be confused with *T. retifera* and it allies because of the presence of more marginal spines and the frill on the keel.

Comparing *T. getzi* with *T. spinosa*, beside the common possession of keel spines, we find but little chance for confusion since the latter has two sets of marginal spines. There is more resemblance to *T. praemorsa* both in the shape, size, and distribution of the reticulations and particularly in the scalloped frill on the keel, but right here we find an easy way to distinguish the two; *T. getzi* has perhaps a dozen spines or scallops along the keel while *T. praemorsa* has only about seven.

The specific name is given in recognition of the interest of Noah L. Getz in collecting the fossils, as rock was quarried on his farm, which resulted in the finding of this and many other fine specimens.

Horizon and locality.—Lower Cambrian, Kinzers formation; (loc. 12x) near Rohrerstown, Pennsylvania.

Holotype.—Cat. No. 10044, Peabody Museum, Yale University.

TUZOIA ? DUNBARI, new species

Plate 7, figure 1

A single specimen from the Kinzers formation represents another species that should, perhaps, be referred to a new genus. The specimen is an impression of the exterior of an extremely spinose form. I am unable to decide whether this represents an entire valve, in which case it, of course, belongs to a new genus, or whether it comprises only that part of the shell between the dorsal line and the keel.

Comparing this form with the more spinose species of *Tuzoia*, we note first the extraordinary extension of the dorsal line into long, upturned spines such as we find in some living crustacea. Assuming that the longer spines occur on the rear margin and that the outer edge extends only to the keel, we note the very long spine in the usual position between the dorsal extension and the keel. If this is only the inner part of the test one or more marginal spines should occur beyond the keel. At least five spines edge the anterior margin exclusive of the dorsal extension. If the foregoing interpretation of the shell is correct, then the broad-based spine along the lower margin belongs to the keel and would indicate the presence of a frill.

The specific name is given in honor of Dr. Carl O. Dunbar, of Yale University, who so kindly permitted me to describe this fossil in this study of the group to which it belongs.

Horizon and locality.—Lower Cambrian, Kinzers formation: (loc. 12x) near Rohrerstown, Pennsylvania.

Holotype.—Cat. No. 10046, Peabody Museum, Yale University.

ANOMALOCARIS Whiteaves

ANOMALOCARIS PENNSYLVANICA, new species

Plate 5, figure 5

A small, poorly preserved example of this peculiar animal was secured from the Kinzers formation in Pennsylvania and placed in Doctor Walcott's collections many years ago. Little can be said about it since its characters are not well shown, but the observation may be made that the appendages, of which there are 12 or 13 pairs, are relatively longer than in any of the described species. The rear segment appears to be rather deeply notched.

Horizon and locality.—Lower Cambrian, Kinzers formation; (loc. 12x) near Rohrerstown, Pennsylvania.

Holotype.—Cat. No. 80487, U.S.N.M.

ANOMALOCARIS CRANBROOKENSIS, new species

Plate 2, figure 4

Only one specimen of this form has been found in the Eager formation. This species has about fourteen or fifteen abdominal segments and blunter appendages than *A. pennsylvanica.* The caudal segment is much like that figured by Walcott [9] for *A. whiteavesi.*

This like the preceding specimen is not well preserved so that it is difficult to determine its features. The interesting thing in this connection is the occurrence of these rare animals in such old beds and associated in both cases with *Tuzoia.*

Horizon and locality.—Lower Cambrian, Eager formation; (loc. 67g) near Cranbrook, British Columbia.

Holotype.—Cat. No. 80479, U.S.N.M.

Genus PROTOCARIS Walcott, 1884

Protocaris Walcott, 1884, Bull. U. S. Geol. Surv., No. 10, p. 50.
Protocaris, Walcott, 1886, Bull. U. S. Geol. Surv., No. 30, p. 147.
Protocaris Woodward, 1888, Mon. British Pal., Phyllopoda, Pal. Soc., p. 2.

Walcott's drawing of the genotype published in 1884 has been copied many times and much has been written about it. The single carapace of *Roddyia* described in the following pages brought up the question whether or not it was a *Protocaris.* It was quite a surprise on looking at that specimen for the first time, to note at once that it had two valves and was almost conspecific with the Burgess shale *P. pretiosa.* Since hitherto *P. marshi* was always regarded as an *Apus*-like form with an undivided carapace, naturally the previous descriptions need revision. Walcott, however, indicated a possible relationship of this primitive crustacean with "the Nebalidae

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[9] Canadian Alpine Journ., vol. 1, no. 2, 1908, pl. 2, fig. 4.

through *Hymenocaris*, *Peltocaris*, *Ceratocaris*." Thus, while this form was classified with *Apus* its true position was hinted at from the beginning.

The better preserved Burgess shale specimen allows us to get a more complete conception of the major features.

Genotype.—Protocaris marshi Walcott. (See pl. 6, figs. 1, 2.)

Geographic and stratigraphic distribution.—Lower and Middle Cambrian. Vermont and British Columbia.

PROTOCARIS PRETIOSA, new species

Plate 4, figures 1, 2

A single Burgess shale specimen preserving the soft body, both within the carapace and the abdominal portion that extended beyond, apparently belongs to the genus *Protocaris*.

Both valves of the carapace are preserved. The left one is flattened out evenly, but the right is crushed in an oblique direction. In general shape and the presence and position of a keel, this shell conforms to *Tuzoia* but both reticulations and marginal spines are lacking.

It was possible to remove the matrix that had filtered between the carapace and the soft body of the animal within and which preserved an impression of the underside of the left valve, thus exposing the body itself. None of the head parts are well shown, since in flattening the original convexity the anterior portion was crowded together, thereby effacing the delicate structures. Omitting the head parts the remainder of the body is divisible into a thoracic division with numerous segments all limb-bearing, an abdominal portion also composed of many segments which appear to have had much shorter or no appendages and finally a third bifurcated caudal division. This latter has practically the same shape as is *Waptia fieldensis*.

Comparing this species with the genotype, *P. marshi*, we can see but few important differences. This new species seems to have the valves more rounded in front, but *P. marshi* is crushed down on the sides and may thereby be somewhat changed from its original outline. The different aspect of the abdominal portions of the two species is accounted for by the fact that *P. marshi* was flattened vertically while *P. pretiosa* suffered pressure at an oblique angle.

Horizon and locality.—Middle Cambrian, Burgess shale; (loc. 35k) near Field, British Columbia.

Holotype.—Cat. No. 80483, U.S.N.M.

RODDYIA, new genus

While the single specimen on which this genus is based leaves much to be desired, it is so unlike anything else from these beds or that has

previously been described that its description and naming seems desirable.

The undivided carapace, the apparent structure features that appear as elevations on the test and its surface ornamentation all indicate that it is a merostome. If so it is considerably older than any of this group hitherto found.

Such generic characters as may be observed will be presented in the specific description.

The name is given as a slight recognition of the important work done for many years by Dr. H. Justin Roddy, now curator of the museum and professor of geology at Franklin and Marshall College, in discovering the interesting fossils occurring in the Lower Cambrian of the Lancaster region. Doctor Roddy has the happy faculty of interesting people in natural science and therefor the author, together with hundreds of others, owes much to him for his unfailing encouragement in the early years of geologic work.

Genotype.—*Roddyia typa*, new species.

Range.—Lower Cambrian. Southeastern Pennsylvania.

RODDYIA TYPA, new species

Plate 2, figure 5

Cephalic shield undivided. The prominences noticeable in the specimen may represent a raised central portion lobed somewhat in the manner of *Aglaspis*.[10] Surface covered with slightly irregular raised lines.

This form should be compared with *Molaria*, *Habelia*, and *Emraldella* of the Burgess shale, but none of these preserve their cephalic shields sufficiently well to make any real comparisons. So far as may be ascertained *Roddyia* seems to be more like *Molaria* than the others, but even then the similarity is only superficial.

Horizon and locality.—Lower Cambrian, Kinzers formation; (loc. 12x) near Rohrerstown, Pennsylvania.

Holotype.—Cat. No. 80480, U.S.N.M.

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[10] See Whitfield, 1882, Geol. Surv. Wisconsin, vol. 4, p. 192, pl. 10, fig. 11.

DESCRIPTION OF PLATES [11]

PLATE 1

FIG. 1. Left valve retaining the three large rear spines. In this specimen the keel was pressed down toward the lower margin, giving it a more curved shape and a more ventral position than it had in a perpendicular view of the undistorted shell and thereby the reticulations have been almost obliterated in the crushed portions and nearly effaced in places beyond this area. A specimen of the abundant gastropod, *Scenella varians*, projects through the shell near its lower margin. Plesiotype, Cat. No. 80484, U.S.N.M.

2. A new photograph of the original holotype figured by Walcott. In this specimen the larger marginal spines are apparently broken off. The keel is pressed almost vertically downward, thereby causing but little distortion on any part of the shell except near the front end where the reticulations show crowding. An examination of the margin indicates that both valves are present. Holotype, Cat. No. 57720, U.S.N.M.

Middle Cambrian, Burgess shale; (loc. 35k) near Field, British Columbia.

PLATE 2

FIG. 1. A well preserved specimen with the left valve uppermost. In the flattening the keel was crushed down directly to the rear. Note the three strong marginal spines and the rather regular smaller spines along the remainder of the outer margin; also the absence of intermediate spines. Several of the blunt spines along the dorsal line can be seen. Holotype, Cat. No. 80477, U.S.N.M.

Middle Cambrian, Burgess shale; (loc. 35k) near Field, British Columbia.

2. Cast of exterior of rear portion of left valve, showing the four large posterior spines. Some of the smaller more regular spines are visible forward along the lower margin. Paratype, Cat. No. 80478, U.S.N.M.

3. Major portion of right valve. Several intermediate marginal spines are visible anterior to the fourth large posterior spine. Holotype, Cat. No. 80478, U.S.N.M.

Middle Cambrian, Burgess shale; (loc. 35k) near Field, British Columbia.

4. Usual lateral view of this animal. Twelve or thriteen segments anterior to the bifurcated caudal division. Somites and appendages may not be quite correctly outlined as specimen is little distinct from matrix. Holotype, Cat. No. 80479, U.S.N.M.

Lower Cambrian, Eager formation; (loc. 67g) near Cranbrook, British Columbia.

5. Dorsal view of cephalic shield (×2). Holotype, Cat. No. 80480, U.S.N.M.

Lower Cambrian, Kinzers formation; (loc. 12x) near Rohrerstown, Pennsylvania.

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[11] All figures are natural size unless otherwise indicated.

Plate 3

Page

Tuzoia burgessensis, new species 8

Fig. 1. A large left valve. Keel pressed directly downward. Folding to accommodate this reduction in convexity resulted in a crowded zone about half way to the margins. Paratype, Cat. No. 80477, U.S.N.M.

Middle Cambrian, Burgess shale; (loc. 35k), near Field, British Columbia.

Tuzoia manchuriensis, Resser and Endo MSS 9

2. Upper anterior quadrant of left valve. Note long extension of dorsal line and narrowed keel. Paratype, Cat. No. 80481, U.S.N.M.

3. Major portion of left valve. Reticulations on keel and general surface partially visible. Note worm borings. Holotype, Cat. No. 80482, U.S.N.M.

Middle Cambrian, Matrix; soft yellow shale. Fig. 2, from Huo-lien-chai, and fig. 3, from Mount Tang-shih-ling, near Yen-tai, Manchuria.

Plate 4

Protocaris pretiosa, new species 13

Fig. 1. Abdominal portion of body and both valves of this interesting form. Right valve extended and practically undistorted. Left valve which rests at an oblique angle to the bedding plane crushed down and thereby extended rearward.

2. Counterpart of same specimen as figure 1, with shell removed to expose most of the body. Note the numerous segments and the bifurcated caudal extremity. Holotype, Cat. No. 80483, U.S.N.M.

Middle Cambrian, Burgess shale; (loc. 35k) near Field, British Columbia.

Tuzoia retifera, Walcott 7

3. Major portion of a poorly preserved specimen referred to the species with some doubt, in which the two valves became flattened out on the same plane. In this case the original convexity of each valve was reduced by overthrust faulting along the keel, together with parallel folding in other areas thus almost effacing the reticulations. Plesiotype, Cat. No. 80484, U.S.N.M.

Middle Cambrian, Burgess shale; (loc. 35k) near Field, British Columbia.

Plate 5

Tuzoia polleni, new species 9

Fig. 1. Large right valve in which the spines and reticulations are well preserved. Holotype, Cat. No. 80485, U.S.N.M.

2. Small right valve from which the marginal spines have mostly been broken away. Note the numerous small and embryonic specimens of a Mesonacid showing on and through the thin shell. Paratype, Cat. No, 80485, U.S.N.M.

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FIG. 3. A third somewhat larger right valve with the cast of the exterior of the left shown in the upper front corner. Note the large spines along the dorsal line. Paratype, Cat. No. 80485, U.S.N.M.

Lower Cambrian, Eager formation; (loc. 67g) near Cranbrook, British Columbia.

Tuzoia nodosa, new species ---------- 10

4 (× 2). Small right valve. Note the very large dorsal spines and those on the keel. Holotype, Cat. No. 80486, U.S.N.M.

Lower Cambrian, Eager formation; (Loc. 67g) near Cranbrook, British Columbia.

Anomalocaris pennsylvanica, new species ---------- 12

5 (× 2). Side view of animal. Specimen poorly differentiated from rock hence the poor illustration. Holotype, Cat. No. 80487, U.S.N.M.

Lower Cambrian, Kinzers formation; (loc. 12x) near Rohrerstown, Pennsylvania.

PLATE 6

Protocaris marshi Walcott ---------- 12

FIG. 1. Unretouched photograph of the single specimen.

2. Retouched photo of same, to bring out certain features that may be seen only by turning the specimen at various angles to the light. Holotype, Cat. No. 15400, U.S.N.M.

Lower Cambrian; (Loc. 25) Georgia, Vermont.

Tuzoia praemorsa, new species ---------- 10

3. Valves flattened into one plane. Distal portions beyond keel folded underneath. Note how the broad keel spines unite to form a wide frill. Surface covered with fine pseudomorphic needle crystals. Holotype, Cat. No. 80488, U.S.N.M.

Middle Cambrian, Burgess shale; (loc. 35k) near Field, British Columbia.

Tuzoia spinosa, new species ---------- 10

4. Fragments of two valves. Keel spines on right-hand specimen preserved in unremoved matrix, overhanging outer portion of shell. Rock bright red and hence difficult to photograph. Holotype, Cat. No. 80489, U.S.N.M.

Lower Cambrian, Eager formation; (loc. 67g) near Cranbrook, British Columbia.

PLATE 7

Tuzoia? dunbari, new species ---------- 11

FIG. 1. Impression of exterior of valve. Note the extraordinary spines. Reticulations faint and difficult to photograph because outlined in bright yellow. Holotype, Peabody Museum, Yale University, No. 10046.

Lower Cambrian, Kinzers formation; (loc. 12x) near Rohrerstown, Pa.

Page

Tuzoia praemorsa, new species---------------------------------- 10

FIG. 2. Valves opened out. Keel, with frill, of right valve fully extended. Outer portion of left valve crushed down almost vertically. Fragment of soft body of some undetermined form at rear. Paratype, Cat. No. 80488, U.S.N.M.

Middle Cambrian, Burgess shale; (loc. 35k) near Field, British Columbia.

Tuzoia getzi, new species---------------------------------- 10

3. Dorsal view of opened valves. Seven spines along dorsal line well shown. Impression of interior, beyond keel, of left valve shown near bottom of picture. Keels with frills flattened out. Holotype, Peabody Museum, Yale University, No. 10044.

Lower Cambrian, Kinzers formation; (loc. 12x), near Rohrerstown, Pennsylvania.

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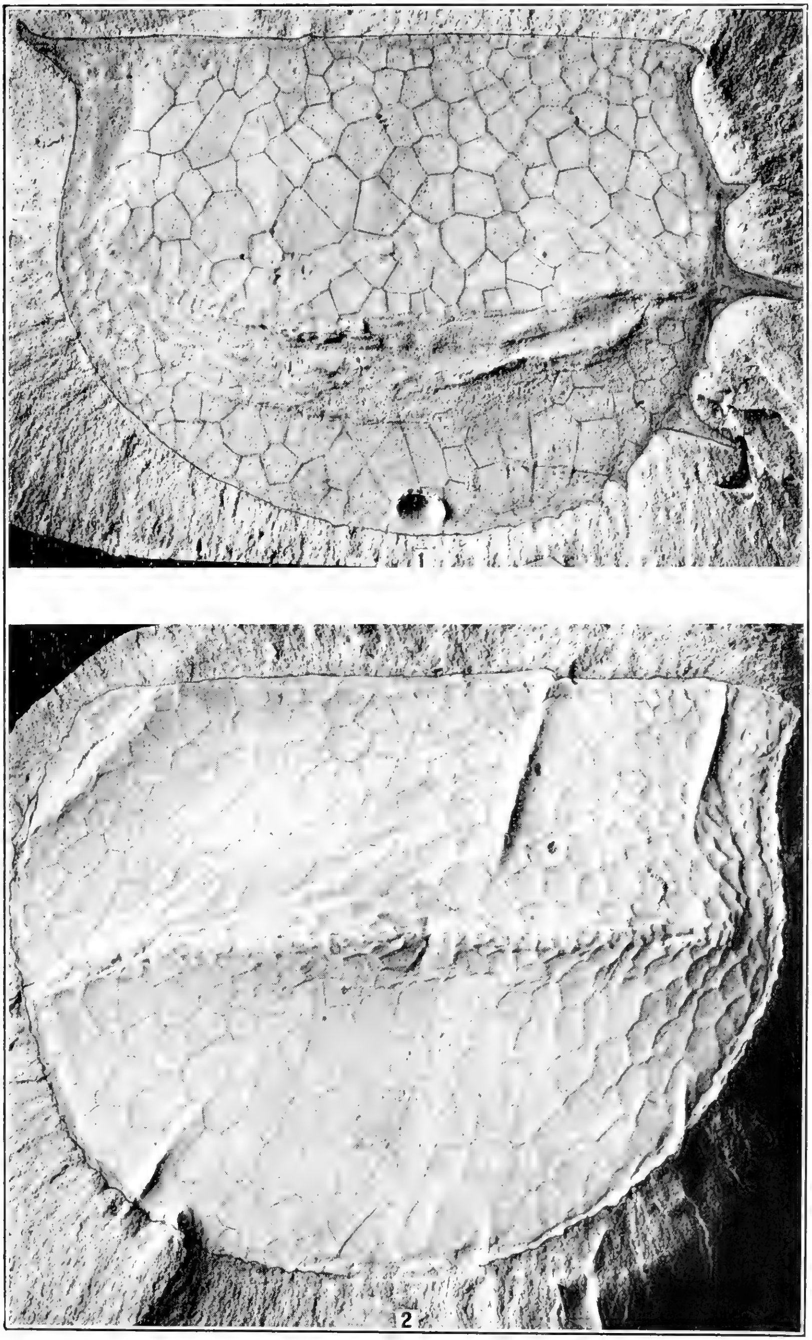
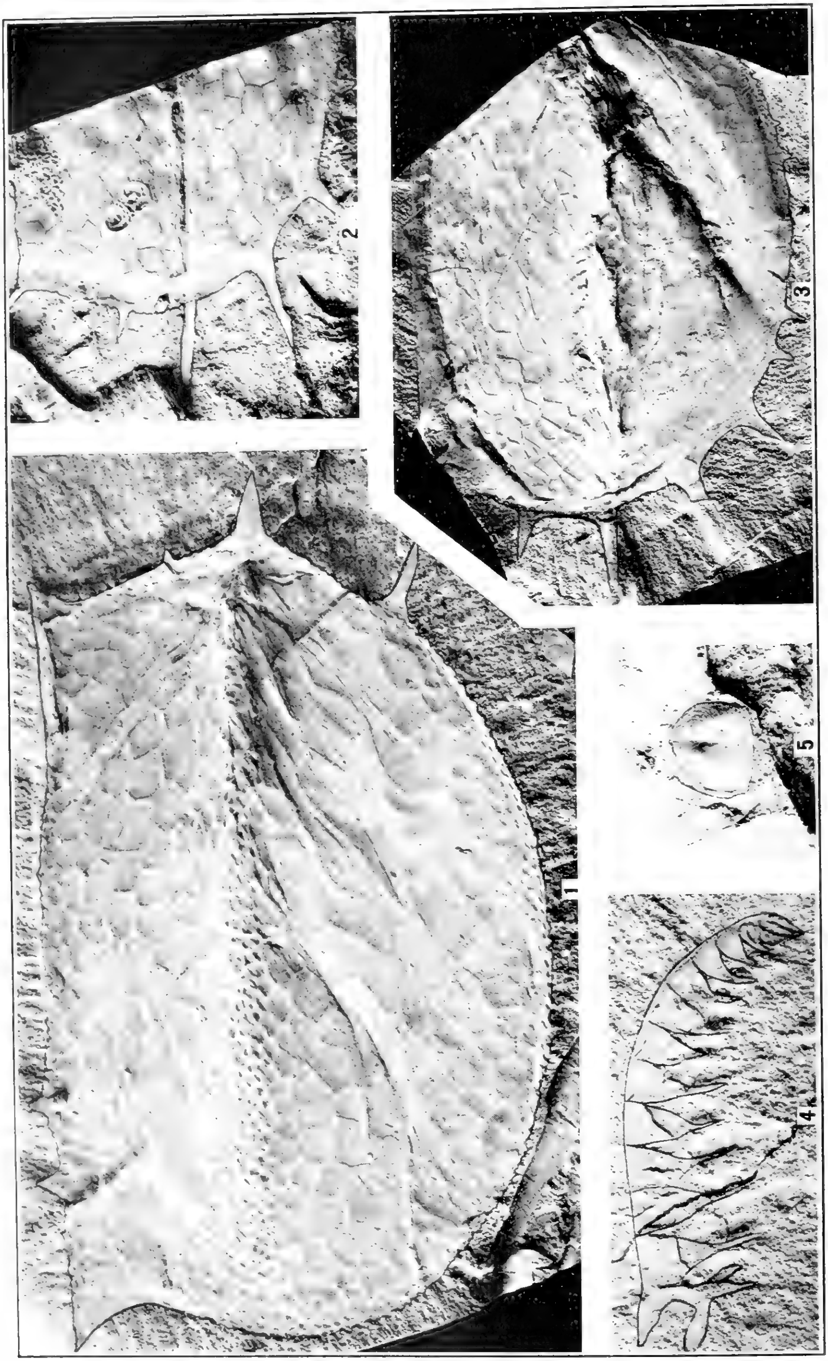


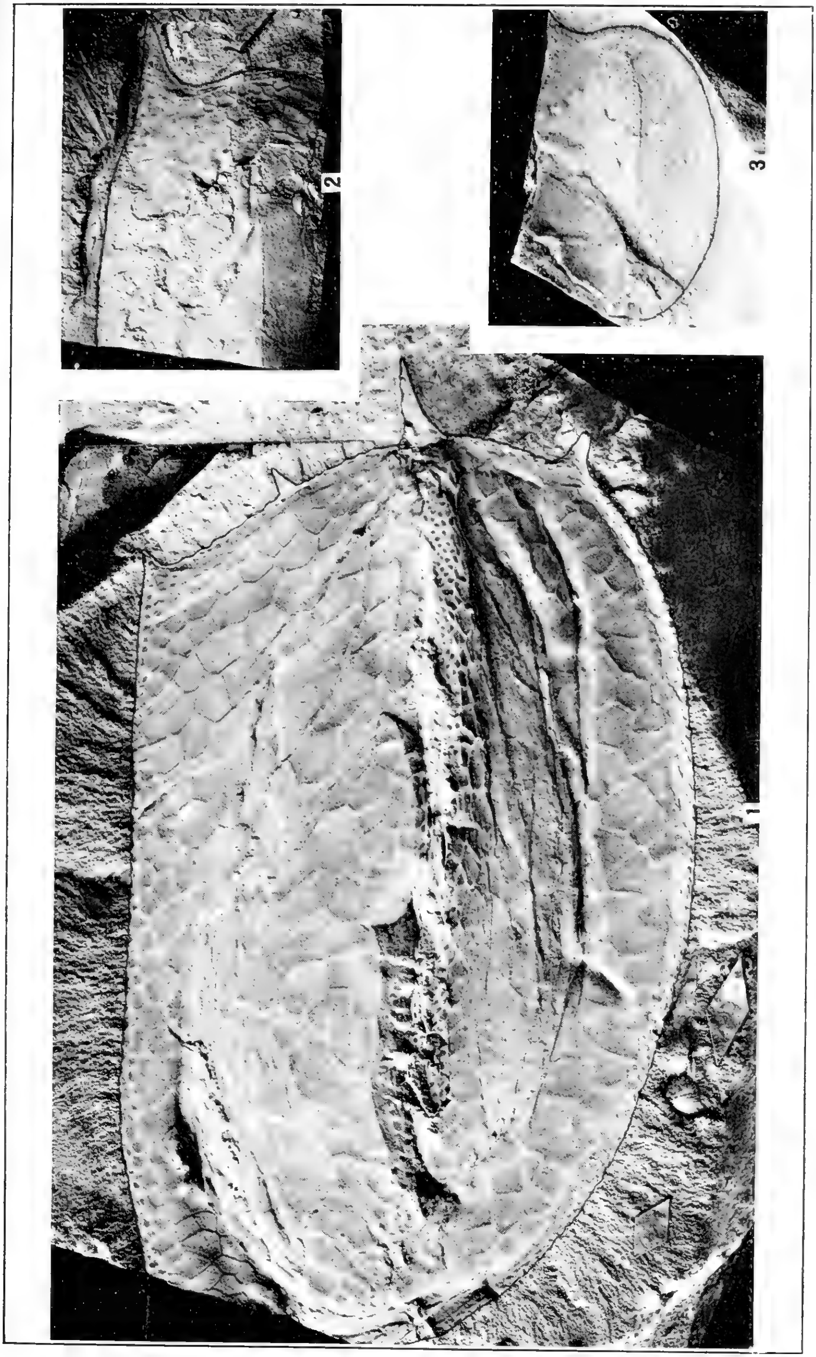
TUZOIA RETIFERA WALCOTT

FOR EXPLANATION OF PLATE SEE PAGE 15



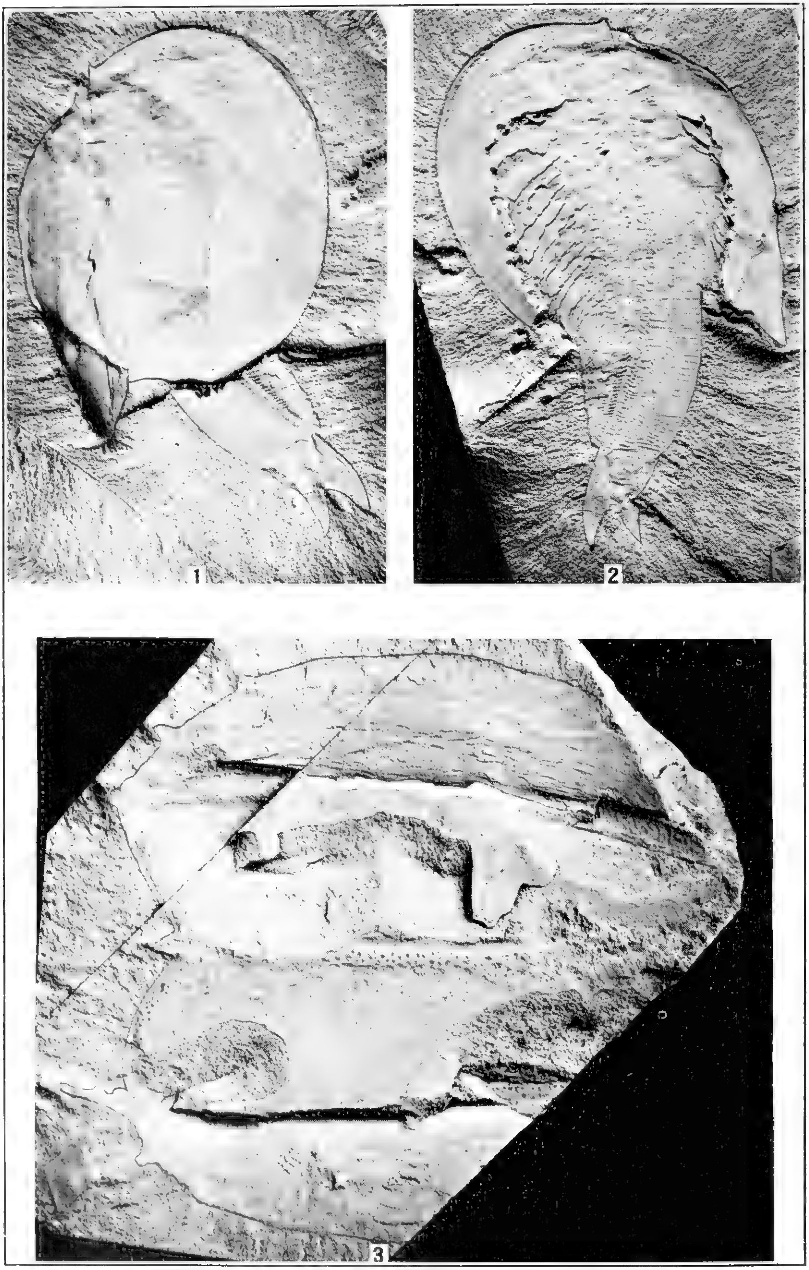
MIDDLE AND LOWER CAMBRIAN CRUSTACEA

FOR EXPLANATION OF PLATE SEE PAGE 15



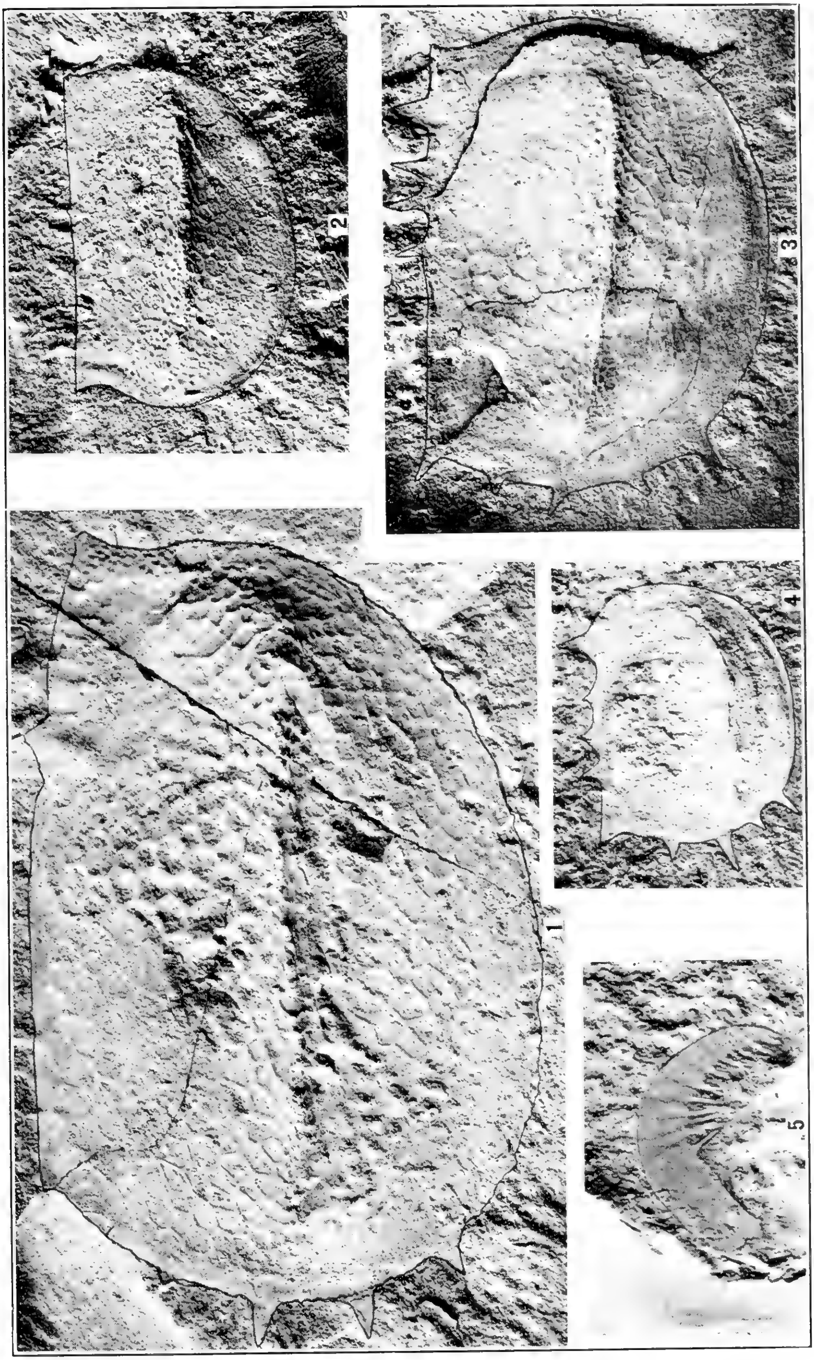
TUZOIA FROM BRITISH COLUMBIA AND MANCHURIA

FOR EXPLANATION OF PLATE SEE PAGE 16



BURGESS SHALE CRUSTACEA

FOR EXPLANATION OF PLATE SEE PAGE 16

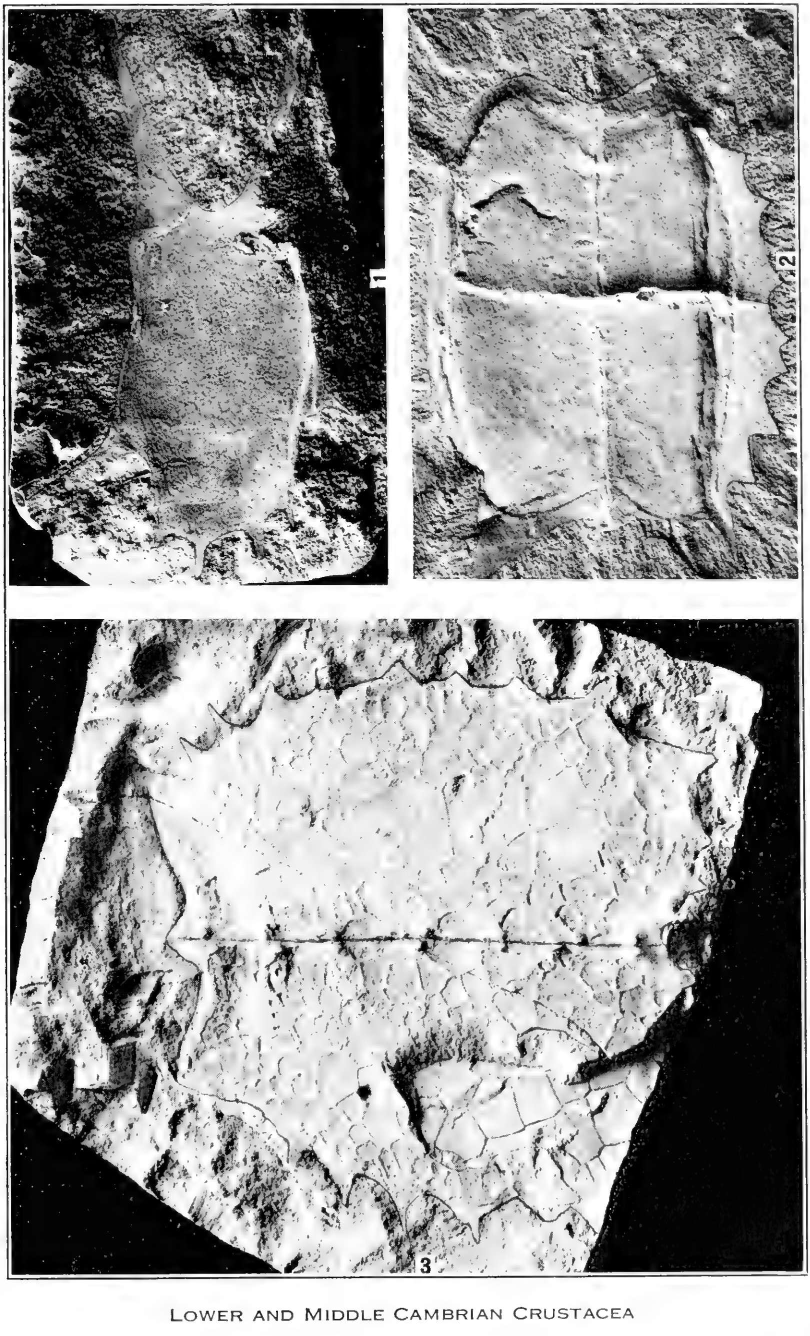


LOWER CAMBRIAN CRUSTACEA

FOR EXPLANATION OF PLATE SEE PAGES 16 AND 17

LOWER AND MIDDLE CAMBRIAN CRUSTACEA

FOR EXPLANATION OF PLATE SEE PAGE 17



LOWER AND MIDDLE CAMBRIAN CRUSTACEA

FOR EXPLANATION OF PLATE SEE PAGES 17 AND 18

NOTES ON THE SPECIES OF MYCTOPHINE FISHES REPRESENTED BY TYPE SPECIMENS IN THE UNITED STATES NATIONAL MUSEUM

By Albert Eide Parr
Of the Bingham Oceanographic Laboratory of Yale University

INTRODUCTION

In a report published in 1928 on the deep-sea material of the order Iniomi obtained by the third oceanographic expedition of the *Pawnee*, under the direction of Harry Payne Bingham,[1] the author has endeavored to arrange all previously described species into complete analytical keys to the various families of which representatives were found in the investigated collections. For this purpose the available published descriptions had to be entirely relied upon for the taxonomic definition of the various forms included in the synoptic reviews, except in the cases where the single species were also represented in the Bingham Oceanographic Collection; criticism being otherwise only applied when obvious discrepancies were found to exist in the literature. In the case of the subfamily Myctophinae the earlier descriptions have, however, often proved to be rather inadequate and sometimes also inaccurate or even directly misleading. This holds particularly good of the descriptions rendered before the modern method of describing and classifying the fishes in question, first introduced by Lütken (1892), had won general recognition through the publication of Brauer's significant and extensive report on the deep-sea fishes obtained by the "Valdivia" expedition (Brauer 1906). When recently visiting the United States National Museum in connection with the preparation of further reports on the Bingham Oceanographic Collection, the author therefore took advantage of the opportunity to investigate the numerous type specimens of the said subfamily deposited in the former institution; the purpose of the investigation being to verify, supplement, or correct the original and current descriptions of the various species involved. The results of this investigation will be presented on

[1] Bulletin of the Bingham Oceanographic Collection, Yale University, vol. 3, art. 3.

the following pages, and it is hoped by the author that, with these observations supplementing the keys to the genera *Myctophum*, *Lampanyctus*, *Diaphus*, and *Lampadena*, already previously rendered in the above-mentioned report, a not only practical but also reliable foundation shall have been laid down for the future identification of most of the formerly deplorably confused species pertaining to the said four genera, which together constitute the subfamily Myctophinae.

The abbreviations first introduced by Brauer (1906) for the designation of the various groups or series of photophores will be used throughout in the following notes, in accordance with the practice now generally accepted in the modern literature on these

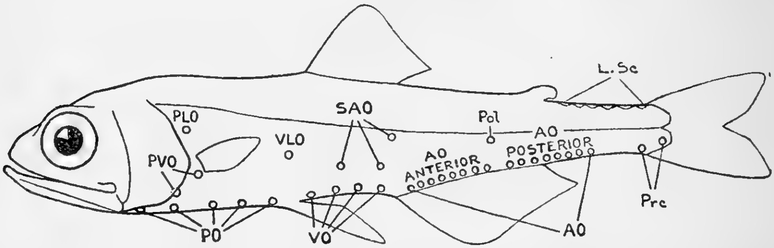


FIGURE 1.—DIAGRAMMATIC DRAWING ILLUSTRATING THE TERMINOLOGY OF THE LUMINOUS ORGANS AS APPLIED TO MYCTOPHUM CALIFORNIENSE (COMPARE WITH FIG. 4). L. SC.=SUPRACAUDAL LUMINOUS SCALES. EXPLANATION OF OTHER LETTERS IN THE TEXT

fishes.[2] The accompanying diagram and list of the abbreviations will sufficiently explain their use and meaning.[3]

PLO=suprapectoral organ.
PVO=subpectoral organs.
PO=thoracic organs.
VLO=supraventral organ.
VO=ventral organs.
SAO=supra-anal organs.
AO=anal organs.
  AO ant.=antero-anal organs.
  AO post.=postero-anal organs.
Pol=postero-lateral organ(s).
Prc=praecaudal organs.

The synoptic reviews of the four genera in question, given in the above-mentioned report upon the Bingham Oceanographic Collec-

[2] Zugmayer 1911, Taaning 1918 and 1928, Barnard 1925, Parr 1928, and others.

[3] The fact that the abbreviations do not always correspond to the full terms employed in the different languages has been intentionally disregarded in the literature for the advantage of obtaining fixed international designations for the organs in question.

tion, will be referred to in the following as "the previously rendered keys." The same arrangement of the species will be used.

SYNOPSIS OF CONTENTS AND CONCLUSIONS

1. Partial or complete redescriptions, with diagrammatic illustrations are rendered of the following distinct species, which have heretofore remained inadequately or incorrectly defined in the literature:

Myctophum crenulare Jordan and Gilbert.
Lampanyctus güntheri Goode and Bean.
Lampanyctus mexicanus Gilbert.
Lampanyctus nannochir Gilbert.[4]
Lampanyctus alatus Goode and Bean.
Diaphus urolampus Gilbert and Cramer.
Diaphus rafinesquei Cocco.[5]
Diaphus chrysorhynchus Gilbert and Cramer.
Diaphus watasei Jordan and Starks.
Diaphus effulgens Goode and Bean.

2. In addition to the above, diagrammatic figures are rendered of the following, not formerly illustrated species:

Myctophum californiense Eigenmann and Eigenmann.
Myctophum imitator Parr (=*M. suborabitale* Gilbert).
Lampanyctus microchir Gilbert.
Lampanyctus punctatissimus Gilbert.
Lampanyctus regalis Gilbert.
Diaphus nipponensis Gilbert.
Diaphus tanakae Gilbert.

3. The following new species and subspecies are defined:

Myctophum fibulatum proximum.

Lampanyctus taaningi, new name, to designate the form currently identified as *Lampanyctus gemmifer* Goode and Beane, the type of Goode and Bean's nominal species being found to actually represent *Lampanyctus crocodilus* Risso.

4. The following, previously established synonymies have been verified on the type specimens:

Myctophum tenua Eigenmann and Eigenmann, synonym of *M. crenulare* Jordan and Gilbert.

Myctophum gilberti Evermann and Seale, synonym of *M. pterotum* Alcock.

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[4] With footnote discussion of the type specimen of the distinct *L. leucopsarus* Eigenmann and Eigenmann in the Museum of Comparative Zoölogy, Cambridge, Mass.

[5] Represented by the type specimens of *D. theta* Eigenmann and Eigenmann, *D. protoculus* Gilbert, and *D. nanus* Gilbert.

Centrobranchus gracilicaudus Gilbert, synonym of *M. andreae* Lütken.

Rhinoscopelus oceanicus Jordan and Evermann, synonym of *M. affine* Lütken.

Myctophum margaritatum Gilbert, synonym of *M. affine* Lütken.

Myctophum braueri Gilbert, synonym of *M. reinhardti* Lütken.

Myctophum remiger Goode and Bean, synonym of *M. hygomi* Lütken.

Notoscopelus brachychir Eigenmann and Eigenmann, synonym of *Lampanyctus elongatus* Costa.

Notoscopelus quercinus Goode and Bean, synonym of *L. elongatus* Costa.

Lampanyctus lacerta Goode and Bean, synonym of *L. dumérili* Bleeker.

Myctophum protoculus Gilbert, synonym of *Diaphus rafinesquei* Cocco.

Diaphus nanus Gilbert, synonym of *D. rafinesquei* Cocco.

5. The status of the following specific designations as synonyms of previously described species can be established for the first time:

Myctophum townsendi Eigenmann and Eigenmann, synonym of *Lampanyctus warmingi* Lütken.

Lampanyctus gemmifer Goode and Bean, synonym of *L. Crocodilus* Risso.

Diaphus theta Eigenmann and Eigenmann, synonym of *Diaphus rafinesquei* Cocco.

6. Due to incorrect original descriptions or figures the following species were found to have been recently redescribed under new names, which must now be included in their synonymies:

Lampanyctus güntheri Goode and Bean redescribed as *L. melanothorax* by Parr 1928.

Lampanyctus alatus Goode and Bean redescribed by *L. pseudoalatus* by Taaning 1928.

7. For similar reasons the type specimen of *Lampanyctus gemmifer* Goode and Beane proved entirely foreign to the species currently identified by this name, and for which the new specific name of *Lampanyctus taaningi* is therefore introduced, while *L. gemmifer* Goode and Bean must be placed among the synonyms of *L. crocodilus* Risso.

8. The following species, currently regarded as synonymous with other forms of earlier description, could be reestablished as distinct from the latter:

Lampanyctus macdonaldi Goode and Bean.

Lampanyctus alatus Goode and Bean.

Diaphus watasei Jordan and Starks.

9. The taxonomic status of *Myctophum andreae* Lütken and *Lampanyctus ritteri* Gilbert, Fowler's records of *Myctophum affine* from Hawaii (Fowler 1928, p. 69), the variations of *Diaphus rafinesquei* Cocco, and other items of minor importance are discussed.

10. The original or current definitions are verified without further discussion on all type specimens deposited in the United States National Museum, representing species of the subfamily Myctophinae not specially mentioned in any of the above lists.

MYCTOPHUM CRENULARE Jordan and Gilbert, 1883

Tarletonbeania crenularis GILBERT, 1915.
Myctophum crenulare PARR, 1928 (gives full synonymy).
Tarletonbeania tenua EIGENMANN and EIGENMANN, 1891.

Material investigated. Type specimen of *Myctophum crenulare* Jordan and Gilbert, No. 27402 U.S.N.M., Santa Barbara, California. Type specimen of *Tarletonbeania tenua* Eigenmann and Eigenmann, No. 42882, U.S.N.M., Coronados, California.

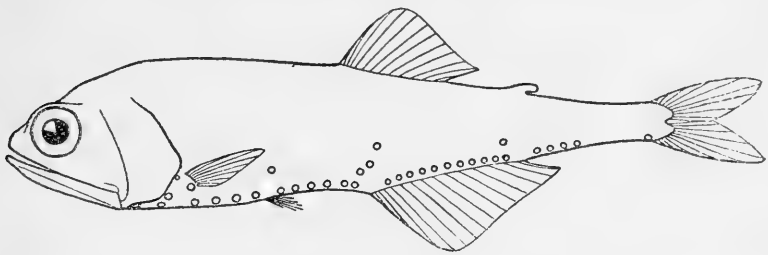

FIGURE 2.—MYCTOPHUM CRENULARE JORDAN AND GILBERT

A very adequate description of *M. crenulare* is rendered by Gilbert 1915 (p. 313), who first established the identity of the two above-mentioned nominal species.

M. crenulare differs from all other species of the genus *Myctophum* by the presence of only one *Prc* and by the absence of pores from all of the lateral line scales except a few of the most anterior ones. It is further characterized by the strong compression of head and body, by the slenderness of the caudal peduncle, and by the nearly rudimentary state of the ventral fins, while the pectorals are well developed.

The type specimen of *Tarletonbeania tenua* shows no significant differences at all from the type of *M. crenulare*, Gilbert's opinion upon the identity of the two has therefore been fully accepted by the author.

The various body proportions of the species are also very characteristic, and rather different from the usual proportions of the genus

Myctophum, particularly with regard to the distances from the snout to the ventral and vertical fins, as will appear from the following table of measurements:

Measurements of M. crenulare Jordan and Gilbert

[In per cent of the total length without caudal fin]

Type of	*Tenua*	*Crenulare*
Total length without caudal fin in mm	61	46
Length of head	26	26. 0
Diameter of eye	8	7. 6
Greatest height	21	24. 0
Length of lower jaw	18	18. 5
Height of caudal peduncle	5	5. 5
Snout to D	51	50. 0
Snout to V	39	39. 0
Snout to A	56	54. 0

The illustration of the species previously rendered by Goode and Bean (1895, fig. 105, pl. 28, *Tarletonbeania tenua*), being rather inadequate and misleading in several respects, the accompanying diagram has been prepared from the above recorded specimens.[6]

Correctly defined in the previously rendered key.

M. crenulare has been taken only off the Pacific coast of North America.

MYCTOPHUM IMITATOR Parr, 1928

Myctophum suborbitale Gilbert, 1913 (name preoccupied, see Parr, 1928, p. 60).

Myctophum simile Taaning, 1928.

Material investigated. Type specimen of *Myctophum suborbitale* Gilbert, No. 74473, U.S.N.M. Suruga Bay, Japan.

The predorsal length of the type specimen is recorded by Gilbert 1913 as 55 per cent of the total length without caudal fin, but was found by the author to be only 45 per cent of the said measurement, the discrepancy probably being due to a misprint in Gilbert's report. The length of the head was likewise found to be probably more nearly 32 per cent of the total length without caudal fin, than 35 per cent as recorded by Gilbert. The distance from snout to ventral fins equals about 41 per cent of the same measurement.

No illustration of the species having previously been rendered the accompanying diagram was prepared from the type specimen.

Correctly defined in the previously rendered key.

Known only from the coast of Japan.

[6] The figure represents a composite diagram, photophores which have become accidentally lost on the left side shown of the type of *M. crenulare*, on which the drawing is primarily based, have been entered by comparison with the right side and with the type of *Tarletonbeania tenua*.

The type of *M. imitator* (suborbitale) is in every respect perfectly concordant with the brief preliminary diagnosis of *M. simile* rendered by Taaning, 1928 (p. 56), and, if the identity of the two should become definitely established by further investigation of the latter form, Taaning's name would have priority over the name of *M. imitator.*

MYCTOPHUM PTEROTUM Alcock, 1891

Scopelus (*Myctophum*) *pterotus* ALCOCK, 1891.
Myctophum pterotum FOWLER, 1928; PARR, 1928 (full discussion of earlier synonymy).
Myctophum gilberti EVERMANN and SEALE 1907.

Material investigated. Type specimen of *Mycotophum gilberti* Evermann and Seale, No. 55900, U.S.N.M. Philippine Islands.

The identity of *M. gilberti* with *M. pterotum* Alcock, already suggested by Gilbert, 1913 (p. 81), could only be confirmed by an inspection of the type specimen of the former species.

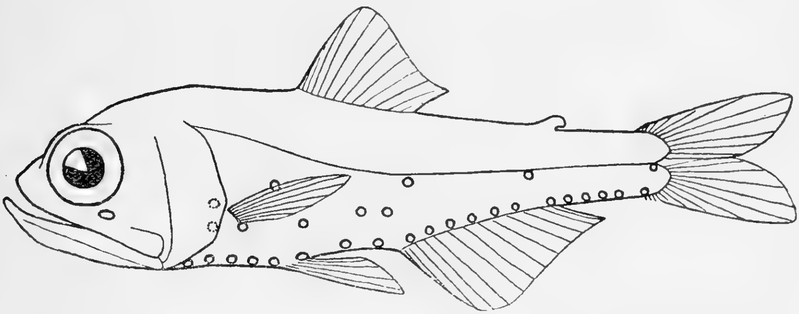

FIGURE 3.—MYCTOPHUM IMITATOR PARR (=M. SUBORBITALE GILBERT)

MYCTOPHUM FIBULATUM Gilbert and Cramer, 1897

Myctophum fibulatum PARR, 1928 (with full discussion of earlier snyonymy, p. 67).

Material investigated. Type specimen No. 47711, U.S.N.M. Hawaii.

A fairly accurate illustration of the type of this species has been rendered with the original description (Gilbert and Cramer, 1897 p. 411, and pl. 38, fig. 2 [7]), and the species has been further discussed in considerable detail by Gilbert 1913 (p. 81, under the heading of *M. pterotum* Alcock).

The type specimen differs somewhat from the specimens previously described and figured by the author (Parr, 1928, p. 67 and fig. 7) in having the *PLO* very close to the lateral line, and by having the last *Pre* immediately below, not directly in the end of the lateral

[7] The legend (pl. 38, fig. 1) erroneously refers this figure to *Diaphus chrysorhynchus*, which is shown in figure 3 on the same plate and is referred to the above-discussed species.

line; while in the material obtained by the Bingham Oceanographic Expedition to the Bahamas, 1927, the *PLO* is considerably closer to the base of pectoral fin than to the lateral line, and the last *Prc* is always directly in the end of the lateral line. In the author's opinion these differences are not sufficiently significant to justify the introduction of an entirely separate species but a subspecific designation of the Atlantic form seems desirable.

The two *PVO* are in both forms arranged in an only very slightly inclined, nearly horizontal series.

Fowler, 1928 (p. 70) still includes *M. fibulatum* among the synonyms of *M. pterotum* Alcock, without giving any reasons for not accepting the arguments rendered by Gilbert 1913 (p. 81) for the distinctness of these two species.

M. fibulatum fibulatum has only been recorded with reliable identification from Hawaiian waters.

MYCTOPHUM FIBULATUM PROXIMUM, new subspecies

Myctophum fibulatum PARR, 1928.

Type specimen, No. 2184 Bingham Oceanographic Collection. Paratype deposited in the United States National Museum.

Distinct from *M. fibulatum fibulatum* by having the *PLO* nearer the base of pectoral fin than to the lateral line, and by having the last *Prc* directly in the end of the lateral line, as above described.

For illustration and further details see Parr, 1928 (pp. 67–69, and fig. 7). The anterior *PVO* is shown in a somewhat too low position in the figure.

Known only from the Tongue of the Ocean, Bahamas.

The species *M. fibulatum* as a whole has been correctly defined in the previously rendered key.

MYCTOPHUM ANDREAE Lütken, 1892

Scopelus (Rhinoscopelus) andreae LÜTKEN, 1892.
Rhinoscopelus andreae GOODE and BEAN, 1895; JORDAN and EVERMANN, 1896.
Myctophum coccoi andreae BRAUER, 1904.
Myctophum andreae BRAUER, 1906, ZUGMAYER, 1911.
Centrobranchus andreae GILBERT, 1911; FOWLER, 1928.
Centrobranchus gracilicaudus GILBERT, 1905; JORDAN and JORDAN, 1922.
Myctophum nigro-ocellatum (part) PARR, 1928.

Material investigated. Type specimen of *Centrobranchus gracilicaudus* Gilbert, No. 51518 U.S.N.M. Hawaii.

The type of *Centrobranchus gracilicaudus* is in every respect perfectly concordant with the description and figure of *Myctophum*

andreae rendered by Lütken, 1892 (p. 245,[8]) and the author can therefore see no reason for maintaining the former as a separate species.

In the previously rendered key to the genus *Myctophum* (Parr, 1928, p. 62) *M. andreae* has become identified with *M. nigro-ocellatum* Günther through an unfortunate misinterpretation of a note upon these two species rendered by Taaning 1928 (p. 55), for which the author must apologize. *M. andreae* and *M. nigro-ocellatum* are easily differentiable from each other by the characters mentioned in the following supplementary key.[9]

I. First (lower) SAO above third VO. AO 4–7+8–12 [10] *M. nigro-ocellatum* Günther 1889.

II. First (lower) SAO above fourth VO. AO 6+11. *M. andreae* Lütken 1892.

The synonymy of *M. nigro-ocellatum* should then read:

Scopelus nigro-ocellatus GÜNTHER, 1889.
Myctophum nigro-ocellatum TAANING, 1928; PARR, 1928 (part).
Centrobranchus choerocephalus FOWLER, 1903 and 1928; GILBERT 1905, 1908, and 1913; JORDAN and JORDAN, 1928.
Myctophum (*Myctophum*) *coccoi* forma *regularis* BRAUER, 1904.
Myctophum (*Myctophum*) *choerocephalum* BRAUER, 1906.

A good illustration of *M. andreae* has been rendered by Gilbert 1905 (pl. 69, fig. 2) ("*Centrobranchus gracilicaudus*"), who also shows a specimen of *M. nigro-ocellatum* ("*Centrobranchus choerocephalus*") on the same plate (fig. 1.).

M. andreae is known from the Indian and Atlantic oceans, and, as *Centrobranchus gracilicaudus*, from the Hawaiian waters and from Japan.

MYCTOPHUM PRISTILEPIS Gilbert and Cramer, 1897

Dasyscopelus pristilepis GILBERT and CRAMER, 1897.
Myctophum pristilepis PARR, 1928 (full synonymy).

Material investigated. Type specimen No. 47737, U.S.N.M. From Hawaii.

The original description and figure of this species (Gilbert and Cramer, 1897, p. 412 and pl. 39, fig. 1) has been supplemented by Gilbert, 1906 (p. 259 and pl. 3), with a very accurate illustration and a detailed discussion of its characters, to which the author has nothing to add. The species has been correctly defined in the previously

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[8] Lütken's figure shows the *SAO* equally spaced, but this feature probably is due to inaccuracy in the drawing and is not mentioned in the text. In the type of *gracilicaudus* the middle *SAO* is distinctly nearer to the lower than to the upper organ of the same series.

[9] To be used for subdivision of point *gg* in the previously rendered key (Parr, 1928, p. 62).

[10] 5–7+9–12, according to Gilbert, 1905, p. 594 ("*Centrobranchus gracilicaudus*"); 4–5+8–9 according to Taaning, 1928, p. 55.

rendered key. Fowler, 1928 (p. 67), combines this species with *M. asperum* Richardson, with which it is very closely related.

The type was obtained in Hawaiian waters. The typical form has later been recorded from near Mauritius (Gilbert, 1906), and an Atlantic subspecies *obtusirostre* is mentioned by Taaning (1928).

MYCTOPHUM CALIFORNIENSE Eigenmann and Eigenmann, 1889

Myctophum californiense JORDAN and EVERMANN, 1896; GILBERT, 1913; TOWNSEND and NICHOLS, 1925, PARR, 1928.
Myctophum humboldti (part) BRAUER, 1906.

Material investigated. Type specimen No. 41920, U.S.N.M. From San Diego, California.

The original description of *M. californiense* Eigenmann and Eigenmann (1889, p. 124) has been very adequately supplemented by Gilbert, 1913 (p. 78), the accompanying diagram of the type specimen, however, represents the first illustration of the species.

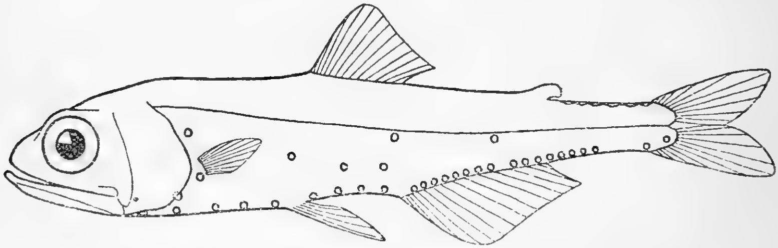

FIGURE 4.—MYCTOPHUM CALIFORNIENSE EIGENMANN AND EIGENMANN

The eyes and the head were found to be slightly larger in the type than in the specimen recorded by Gilbert, equaling 8.5 and 27 per cent, respectively, of the total without caudal fin, instead of 7.8 and 25 per cent of the same measurement.

Correctly defined in the previously rendered key.[11]

Type locality: San Diego, California. Subsequently recorded also from Japan (Gilbert, 1913).

MYCTOPHUM EVERMANNI Gilbert, 1905

Myctophum evermanni BRAUER, 1906; GILBERT, 1908 and 1913; WEBER, 1913, WEBER and BEAUFORT, 1913; JORDAN and JORDAN, 1922; FOWLER, 1928; PARR, 1928.

Material investigated. Type specimen No. 51521, U.S.N.M. From Hawaii.

Adequately described and figured by Gilbert, 1905 (p. 597 and pl. 70, fig. 2).

Correctly defined in the previously rendered key.

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[11] For "The last 3–4 posterior *AO* above the base *A*" (Parr. 1928, p. 64, point *Z*), read "The first 3–4 posterior *AO* above the base *A*."

Known from the waters around Hawaii, from the Indo-Australian Archipelago and from Japan.

MYCTOPHUM AFFINE Lütken, 1892

Scopelus affinis LÜTKEN, 1892.
Myctophum affine GOODE and BEAN, 1895; JORDAN and EVERMANN, 1896; BRAUER, 1904 and 1906; LONNBERG, 1905; GILBERT, 1908, 1911, 1913, and 1915; ZUGMAYER, 1911; FOWLER, 1912, not FOWLER, 1928; WEBER, 1913; WEBER and BEAUFORT, 1913; PAPPENHEIM, 1914; JORDAN and JORDAN, 1922; FOWLER and BALL, 1925; TAANING, 1928; PARR, 1928.
Myctophum opalinum GOODE and BEAN, 1895; JORDAN and EVERMANN, 1896, WAITE, 1903; BREDER, 1927.
Myctophum nitidulum GARMAN, 1899.
Rhinoscopelus oceanicus JORDAN and EVERMANN, 1903.
Myctophum margaritatum GILBERT, 1905.

Material investigated. Type specimen of *Rhinoscopelus oceanicus* Jordan and Evermann, 1902, No. 50622, Hawaii. Type specimen of *Myctophum margaritatum* Gilbert, 1905, No. 51536, Hawaii.

An inspection of the above mentioned types can only serve to verify in every respect the identity of these two nominal species with the cosmopolitan *M. affine* Lütken, as already made out by Brauer, 1906 (p. 190) and by Gilbert, 1908 (p. 217) and 1913 (p. 77).

Fowler, 1928 (p. 69), figures a young specimen (of about 30 mm. length without caudal fin),[12] and describes another, of 72 mm. length, referring both to *M. affine*. These specimens do, however, neither seem identical with each other nor can either one of them be identified with Lütken's *M. affine*, unless the description and figure should be very inaccurate and misleading. The illustration shows a specimen with *prominent snout*, *6 PO*, *4 VO*, *SAO* in a straight series, 10+5 *AO*, only one single *Prc*, anal origin under the anterior part of the base of dorsal fin, the ventrals inserted far in advance of the origin of dorsal fin, and no lateral line. If these features are accurately shown in the drawing the specimen certainly must represent an entirely new species most closely related to the group of *M. coccoi* Cocco, *M. nigro-ocellatum* Günther and *M. andreae* Lütken, but has no relationship at all to *M. affine* Lütken. The larger specimen is on the other hand described as having a " very short " snout, only 6+4 *AO*, 2 *Prc*, and a lateral line. That these two specimens can not be identical if figure and description are both reliable, is obvious without further discussion. That the larger specimen can not either be identical with Lütken's *M. affine* is indicated by the following features. The specimen is described as having " 4 pectorals "; " 2 anterolaterals "; " 5 thoracic "; and " ventrals apparently 3." The fact that there are 5 " thoracics " in addition to the 4 " pectorals " shows that there must be one photophore more on the

[12]According to the scale of the illustration, fig. 13, in his Fishes of Oceania.

anterior part of the body than there is in *M. affine* (which has 1 $PLO+2\ PVO+5\ PO=8$, only, instead of 9). According to the definition of antero-lateral organs (Goode and Bean, 1895, tentative arrangement of the genera of Myctophidae, with diagram and explanation of terms, inserted between pages 70 and 71, *loc. cit.*), the presence of two such photophores as described by Fowler would mean, in modern terms, that the second *VO* is elevated, a condition which also automatically explains the statement that there are apparently only 3 "ventrals," the second *VO* being counted as an antero-lateral. Fowler's larger specimen, therefore, would probably belong in division *B*, II, *e*, 2, *x* (p. 60) in the previously rendered key to the genus *Myctophum* (Parr, 1928), but does not seem to have any relationship to *M. affine*, in which the 4 *VO* are all situated on the same level.

MYCTOPHUM REINHARDTI Lütken, 1892

Scopelus reinhardti LÜTKEN, 1892.
Myctophum reinhardti PARR, 1928 (with full synonymy).
Myctophum braueri GILBERT, 1905.

Material investigated. Type specimen of *Myctophum braueri* Gilbert, No. 51527 U.S.N.M., from Hawaii.

The identity of *M. braueri* Gilbert 1905 (p. 598 and Plate 70, fig. 1[13]) with Lütken's *M. reinhardti* has already been established by Gilbert, 1908 (p. 219), and can only be confirmed by the author after an inspection of the type-specimen of the former nominal species.

MYCTOPHUM HYGOMI Lütken, 1892

Scopelus hygomi LÜTKEN, 1892.
Myctophum hygomi PARR 1928, (with full synonymy).
Myctophum remiger GOODE and BEAN, 1895.

Material investigated. Type lot of *Myctophum remiger* Goode and Bean 1895, No. 43792, 9 specimens from the western Atlantic.

Inspection of the type specimens of *M. remiger* G. a. B. only serves to verify the identity of this form with Lütken's *M. hygomi* as already made out by Jordan and Evermann, 1986, page 573.

The sample showed the following compositions of organs in the anal series, each side being counted separately. $6+7$ *AO* in 4 cases; $7+6$ *AO* in 12 cases; and $7+7$ *AO* in 2 cases (1 specimen). Asymmetry of the nature $\frac{6+7}{7+6}AO$ was found in two specimens.

Known from the Mediterranean, the Atlantic, and the Indian Oceans.

[13] Misnamed *M. lütkeni* in the legend of the figure (see Gilbert, 1908).

LAMPANYCTUS WARMINGI Lütken, 1892

Scopelus (Nyctophus) warmingi LÜTKEN, 1892*b*.
Lampanyctus warmingi PARR, 1928 (with earlier synonymy).
Myctophum townsendi EIGENMANN and EIGENMANN, 1889.
Lampanyctus townsendi PARR, 1928 (with earlier synonymy); FOWLER, 1928.

Material investigated. Type lot of *Myctophum townsendi* Eigenmann and Eigenmann, 1889, No. 41921, U.S.N.M., from Cortez Banks, California.

The largest specimen of the sample of *Myctophum townsendi*, the only one which is still legible, is in every respect perfectly concordant with the Atlantic specimens of *L. warmingi* Lütken (see Taaning, 1928, p. 65, and Parr, 1928, p. 91), both with regard to proportions, photophores, and luminous scales. The latter are found in the same, characteristic arrangement as in *L. warmingi* in a single midventral series between ventral fins and the vent, ending in a symmetrical pair, one on each side of the anal opening, (see also Gilbert, 1913, p. 99). A group of luminous scales below the throat, now lost in the type, has also been described by Gilbert (1913, p. 99). There is a whitish patch above the eye, preserved in a bad condition, only on one side, which may be an artefact or might possibly represent a luminous tissue, similar to the presumably luminous patches found in the same position in *L. photothorax* Parr, 1928. This feature is, however, of a highly questionable nature and taxonomic value, and the investigated lot shows no adequate reason at all for regarding *L. townsendi* as a distinct species from *L. warmingi*.

LAMPANYCTUS MARGARITIFER Goode and Bean, 1895

Notoscopelus margaritifer GOODE and BEAN, 1895.
Macrostoma margaritiferum JORDAN and EVERMANN, 1896.
Myctophum (Lampanyctus) margaritiferum BRAUER, 1906.
Lampanyctus margaritifer PARR, 1928.

Material investigated. Type specimen No. 43775, U.S.N.M. From the northwestern Atlantic.

The original figure of this species (Goode and Bean, 1895, fig. 98, pl. 26) apparently renders a fairly accurate picture of the arrangement of the photophores, being generally correct in as far as it is now possible to check up on the type-specimen. The only obvious difference worth mentioning is contributed by the fact that 5 *VO* in a straight series are found in the type, while only 4 of these organs are shown in the figure. The upper *PVO* has now become lost on both sides, but is shown above the base of the pectoral fin in Goode and Bean's drawing.

Correctly defined in the previously rendered key.

Known only from the Newfoundland Banks.

LAMPANYCTUS ELONGATUS Costa, 1844

Scopelus elongatus COSTA, 1844.
Lampanyctus elongatus PARR, 1928 (with full synonymy).
Notoscopelus brachychir EIGENMANN and EIGENMANN, 1889.
Catablemmela brachychir EIGENMANN and EIGENMANN, 1891.
Notoscopelus quercinus GOODE and BEAN, 1895.
Macrostoma quercinum JORDAN and EVERMANN, 1896.
Myctophum (Lampanyctus) quercinum BRAUER, 1906.

Material investigated. Type specimen of *Notoscopelus brachychir* Eigenmann and Eigenmann, 1889, No. 76336, U.S.N.M. From Cortez Banks, California. Type specimen of *Notoscopelus quercinus* Goode and Bean, 1895, No. 43789, U.S.N.M. From the Newfoundland Banks.

Only a few of the photophores can still be made out with certainty on either of the two above mentioned type specimens, which are in a rather bad condition. There is, however, nothing to refute the view already previously held by the author that *Notoscopelus brachychir* and *quercinus* are both perfectly identical with *Lampanyctus elongatus* Costa, as already made out by Jordan and Evermann, 1896 (p. 556) in the case of the former of the two nominal species.

LAMPANYCTUS CASTANEUS Goode and Bean, 1895

Notoscopelus castaneus GOODE and BEAN, 1895.
Macrostoma castaneum JORDAN and EVERMANN, 1896.
Myctophum (Lampanyctus) castaneus BRAUER, 1906.
Lampanyctus castaneus PARR, 1928.

Material investigated. Type specimen No. 31706, U.S.N.M. From the northwestern Atlantic.

The condition of the type specimen makes it quite impossible to observe any details of specific significance, practically all of the photophores having now become lost. Nothing can therefore be added to the unfortunately rather inadequate original description, and the accuracy of the details shown in the only illustration of this species (Goode and Bean 1895, fig. 95, pl. 25) can not be determined.

LAMPANYCTUS GÜNTHERI Goode and Bean, 1895

Lampanyctus güntheri GOODE and BEAN, 1895; JORDAN and EVERMANN, 1896; WAITE, 1910 (?); PARR, 1928.
Myctophum (Lampanyctus) güntheri BRAUER, 1906; PAPPENHEIM, 1914.
Lampanyctus melanothorax, PARR, 1928.

Material investigated. Type specimen No. 43777, U.S.N.M. Newfoundland Banks.

It appears from an inspection of the above type specimen that the lateral line scales of *L. güntheri* are very much enlarged indeed, particularly on the posterior part of the body, where their broad posterior (free) margins extend over approximately three-fourths,

or more, of the entire height of the caudal peduncle. The fact that the said species was referred by Goode and Bean, 1895, to the genus *Lampanyctus*, in the restricted sense in which this generic designation was employed by the said authors to embrace only the species which combined among other characters the feature of having the scales of the lateral line "scarcely larger than the others," is therefore inexplicable,[14] and has caused the author previously to redescribe the species under the name of *L. melanothorax*. The specimens reported by Waite, 1910, as having the lateral line scales only scarcely enlarged may possibly pertain to another species, if a similar misleading use of these descriptive terms has not also been made by Waite.

The type specimen of *L. güntheri* is in all other respects quite concordant with the material of *L. melanothorax* Parr previously reported upon (see Parr, 1928, p. 99), as will appear from a comparison of the accompanying diagram of the former with the figure and de-

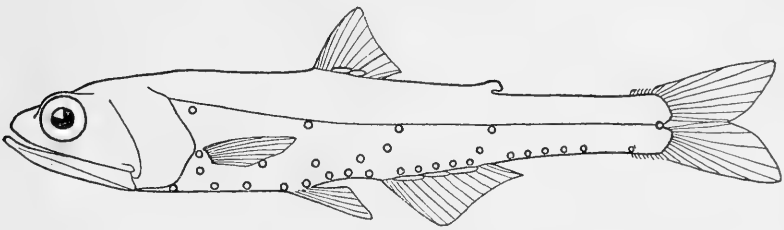

FIGURE 5.—TYPE SPECIMEN OF LAMPANYCTUS GÜNTHERI GOODE AND BEAN. SUPRA- AND INFRA-CAUDAL LUMINOUS SCALES LOST

scription of the latter (*loc. cit.*). Most of the luminous scales, the second and third *Prc*, and possibly the sixth postero-anal organ have become lost, however, in the type of *L. güntheri*, but there is no reason to assume that these organs, when present, would have differed from those of the nominal *L. melanothorax*.

The species has been recorded from Atlantic and Australian waters. *L. gaussi* Brauer 1906, which has been identified with *L. güntheri* by Taaning 1928, differs according to Brauer's description in having 6 *VO* and a luminous scale at the base of ventral fin, while only 5 *VO* and no luminous scale in the said position are found in *L. güntheri*.

LAMPANYCTUS MEXICANUS Gilbert, 1891

Myctophum mexicanum GILBERT, 1891.
Nannobrachium mexicanum JORDAN and EVERMANN, 1896.
Myctophum (*Lampanyctus*) *mexicanum* BRAUER, 1906.
Lampanyctus mexicanus PARR, 1928.

Material investigated. Type specimen No. 76343, U.S.N.M. From the Gulf of California.

[14] The original illustration of the species (Goode and Bean, 1895, fig. 90, pl. 24) is also entirely misleading in this respect.

PLO at the lateral line. First *PVO* well below and anterior to the second *PVO*.[15] 5 *PO*, the fourth elevated approximately to the level of the upper *PVO*. Interspace between first and second *PO* enlarged. *VLO* very low, its distance from the base of ventral fin only about one-third of its distance from the lateral line. 4 *VO*, the second *VO* elevated to the level of the *VLO*. *SAO* broadly angulate. First *SAO* above the interspace between third and fourth *VO*, somewhat nearer to the vertical from the former. Second *SAO* above and behind fourth *VO* and slightly higher than first *SAO*. Third *SAO* at the lateral line, somewhat behind the vertical from second *SAO*. The continuation of the line through second and third *SAO* passes well behind the last *VO*. Only 4 widely spaced antero-anal organs, with the interspaces gradually decreasing caudalwards. None of the antero-anal organs elevated. 2 *Pol*, the upper at the lateral line, well behind the vertical from the lower *Pol*, which is situated well behind and somewhat higher than the last antero-anal organ. The anterior

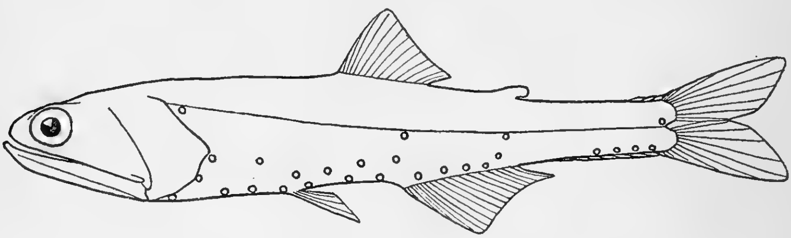

FIGURE 6.—LAMPANYCTUS MEXICANUS GILBERT

organs of the postero-anal series have unfortunately now become lost in the type specimen, but four organs are found on each side on the posterior part of the caudal peduncle in a continuous, horizontal series along the ventral outline of the tail, ending at the bases of the lower caudal rays. These four organs evidently must comprise the posterior postero-anals and the anterior (lower) praecaudals and their arrangement indicates these two series to be perfectly confluent. The ultimate *Prc* is situated close to, but very distinctly above the end of the lateral line. No intermediate organ was found between this upper praecaudal and the above described posterior organ of the ventral series (see figure), but there is a possibility that such organs may originally have been present and have subsequently become lost in the type specimen. This possibility is, however, not confirmed by the original description, according to which there were " six pairs of spots along the under side of tail, and three along base of lower caudal lobe " (Gilbert, 1891, p. 52), when the specimen was

[15] The pectoral fins have practically completely disappeared in this species and their bases can therefore scarcely serve as orientation points for describing the positions of the photophores.

still in a comparatively fresh state of preservation. In modern terms the above quoted description should therefore probably read: Six postero-anals. The three anterior (or lower) *Prc* situated along the base of lower caudal lobe.[16] With further details as above described.

The obscure terminology of the original description has caused the species to be recorded as having 6+6 *AO* (Brauer, 1906, p. 167) or 6+5 *AO* (Parr, 1928, p. 84), the actual numbers being 4+6 (?) *AO*+4 *Prc*, as above made out. Otherwise correctly defined in the previously rendered key.

6–7 infracaudal and 3 supracaudal luminous scales, not elevated on procurrent caudal spines.

The type specimen shows the following proportions in per cent of the total length without caudal fin (44 mm.). Length of head 30. Diameter of eye 6.8. Length of lower jaw 23. Greatest height 18. Distance from snout to dorsal fin 50. Distance from snout to ventral fins 42. Distance from snout to anal fin 60.

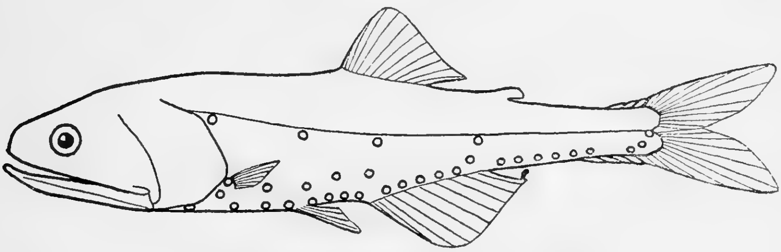

FIGURE 7.—LAMPANYCTUS MICROCHIR GILBERT

The advanced position of the ventrals relative to the dorsal fin, the low position of the *VLO*, the low number of photophores in the antero-anal series and the comparatively few scales are the distinguishing features of the species.

LAMPANYCTUS MICROCHIR Gilbert, 1913

Lampanyctus microchir GILBERT, 1913; PARR, 1928.

Material investigated. Type specimen No. 74468, U.S.N.M. Suruga Bay, Japan.

A fully adequate and very accurate description of this species has already been rendered by Gilbert, 1913 (p. 101), but no illustration has so far been published. The accompanying diagram has therefore been prepared from the type specimen.

Correctly defined in the previously rendered key.

Known only from the type specimen.

[16] The praecaudals being arbitrarily counted as four when they are confluent with the postero-anals (see Parr, 1928, p. 77).

LAMPANYCTUS NANNOCHIR Gilbert, 1891

Myctophum mannochir GILBERT, 1891 (part).
Nannobrachium nannochir (part), JORDAN and EVERMANN, 1896; GILBERT, 1895.
Lampanyctus nannochir GILBERT, 1913, PARR, 1928.
? *Myctophum* (*Lampanyctus*) *leucopsarum* BRAUER, 1906.

Material investigated. Type lot No. 44291, U.S.N.M.[17] 8 specimens from off the coast of the State of Washington.

In spite of the various, quite extensive discussions of its taxonomic status rendered by Gilbert (1895, p. 399; 1913, p. 100, and 1915, p. 315, under *L. leucopsarus*), subsequent to its original description (Gilbert, 1891, p. 51), *L. nannochir* has up to the present date remained a very obscurely and unsatisfactorily defined species. After an inspection of the type sample deposited in the United States National Museum the author is able, however, to verify the specific distinctness of Gilbert's species from the closely related *L. leucopsarus* Eigenmann and Eigenmann[18] as well as from all other forms included in the genus *Lampanyctus*. The following description of the type sample, of which only one specimen is sufficiently well preserved to show the arrangement and numbers of the photophores, may serve for future identification.

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[17] A second type specimen (No. 1459 of the Leland Stanford Junior University Museum, from the same haul as the type-sample in the U.S.N.M.) has also been assigned to the species in a later publication by Gilbert (1895, p. 400), wherein a more restricted definition of *L. nannochir* is rendered. It is obvious, however, that the specimens of *L. leucopsarus*, with which species *L. nannochir* was at first confounded, must have become weeded out of the type sample of the latter species, probably by Gilbert himself, subsequent to the publishing of the original description, as no such specimens are found in the sample to-day.

[18] The author has had opportunity to examine the type of *L. leucopsarus* Eigenmann and Eigenmann in the Museum of Comparative Zoölogy, Cambridge. This specimen differs from the above-discussed type of *L. nannochir* in having the upper *SAO* and *Pol* only about the length of one of their own diameters, or even considerably less (*Pol*), removed from the lateral line; by the presence of 4 *Prc* in an equally curved series, well separated from the postero-anal organs; and by the presence of 5 *VO*, the second being elevated and advanced to a position nearly vertically above the first *VO*. No traces of a *VLO* are found in the type of *L. leucopsarus*, and there seems to be no indication of such organ ever having been present on the specimen. A comparison with the type of *L. nannochir* might further suggest the possibility that the so-called *VLO* of the latter specimen should actually be homologous with the second *VO* of the type of *L. leucopsarus*, this organ having in the former species merely become further elevated and advanced to a position slightly anterior to the vertical from the first *VO*. On the basis of this assumption both species might be defined as having lost their *VLO*. The type of *L. nannochir* must otherwise be defined as distinct from the type of *L. leucopsarus* in having only 4 *VO* as compared to the unquestionable 5 *VO* of the latter, in direct contradiction of the comparative tabulation of the features of these two species given by Gilbert, 1895 (p. 399). Other differences in proportions, etc., claimed by the said author could not be verified on the type specimens, which, on the contrary, seem quite concordant in all measurements. A thorough revision of the various collections referred to each of the respective species is highly desirable to clear the confusion existing in all previous descriptions. The types of both species agree in the practically rectilinear arrangement of the *SAO*, the lower one of which is situated entirely behind the vertical of the last *VO*; and also in having the *Prc* well separated from the postero-anal series.

Total length without caudal fin 97 mim.[19] Proportions in per cent of the total length without caudal fin: Length of head 28. Diameter of eye 6.6. Length of lower jaw 22. Greatest height 19. Distance from snout to dorsal fin 46. Distance from snout to ventrals 40.5. Distance from snout to anal fin 56.

Origin of anal fin below the end of the anterior three-fifths of the base of dorsal fin. The general appearance of the species will be sufficiently evident from the accompanying diagram.

PLO nearer to the lateral line than to the base of pectoral fin. Upper *PVO* vertically above lower *PVO*. 5 *PO*, the fourth elevated to approximately midway between the levels of the upper and the lower *PVO*. The interspace between first and second *PO* enlarged. *VLO* [20] approximately midway between the lateral line and the base of ventral fin, or lower, only slightly in advance of the vertical from

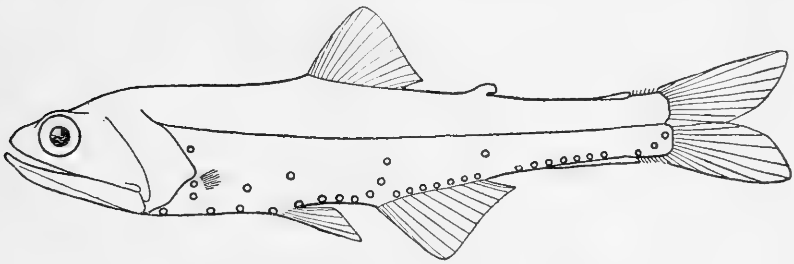

FIGURE 8.—LAMPANYCTUS NANNOCHIR GILBERT

the anterior *VO*. 4 *VO* with gradually decreasing intervals, the first interval being the widest. 3 *SAO* in a very slightly curved, nearly straight, series, with the lower organ well behind and only slightly higher than the fourth *VO*. This lower *SAO* probably represents the fifth *VO* of earlier descriptions. Second *SAO* only slightly nearer to the lower than to the upper *SAO*. Upper *SAO* about 3 of its own diameters below the lateral line canal. 7+7 *AO* (determined by comparison between the different specimens in the type-sample). *Pol* posterior to the vertical from the last antero-anal organ and about 3 of its own diameters below the lateral line canal. The postero-anal series begins at a considerable distance (about equal to two normal photophore-intervals or even more) behind the end of the base of anal fin. 3 *Prc*, well separated from the postero-anal organs and apparently arranged in a nearly straight or only very

[19] The measured specimen, on which the following description and figure are mainly based, carried the tin tags of the sample and probably represents the holotype of the species. Only the numbers and accurate arrangement of the posterior ventral series (*AO* and *Prc*) were determined by comparison with the other specimens.

[20] See footnote 18 on the preceding page.

slightly curved series, with the upper organ somewhat below the end of the lateral line.

The luminous scales are difficult to make out, but it is obvious that the infracaudal scales have occupied considerably more than one-third of the length of the caudal peduncle, as claimed by Gilbert 1895, probably more nearly two-thirds of the same. The supracaudal series, however, has scarcely been more than half the length of the infracaudal series, thus conforming with Gilbert's statement.

The various published records of the species are of highly questionable taxonomic validity.

LAMPANYCTUS MACDONALDI Goode and Bean, 1895

Nannobrachium macdonaldi GOODE and BEAN, 1895; JORDAN and EVERMANN, 1896.

Material investigated. Type specimen No. 39478, U.S.N.M. Northwestern Atlantic.

The above type specimen is in most respects quite concordant with the redescription of Günther's *L. niger*[21] rendered by Brauer, 1906 (p. 242), and differs from the three new species *L. ater*, *L. lineatus* and *L. cuprarius* introduced by Taaning, 1928 in having the *VLO* inserted far below the lateral line. Brauer describes the *VLO* as being situated "ein wenig" (a little, somewhat), below the lateral line in the specimens examined by him, and his figure (1906, fig. 159), shows its distance from the lateral line as only about one-third of its distance from the base of ventral fin. In the type of *L. macdonaldi* the ratio between these two distances equals about 2:3. In *L. macdonaldi* the *PLO* is also inserted approximately midway between the lateral line and the base of pectoral fin, and the two *PVO* are situated nearly vertically above each other; while in Brauer's description and figure of *L. niger* the *PLO* is close to the lateral line and the *PVO* are arranged in a very oblique series with the upper organ well in advance of the lower. For these reasons the author has felt justified in reestablishing *L. macdonaldi* Goode and Bean as a separate species, and the following brief synopsis may serve for its identification, as a supplement to point *zz* (p. 87), in the previously rendered key (Parr, 1928).

v. *VLO* a little or far below the lateral line.

n. *PLO* near the lateral line. *PVO* in an oblique series, with the upper photophore well in advance of the lower. *VLO* much nearer to lateral line than to base of ventral fin.

L. niger (Günther) Brauer, 1906.

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[21] The *L. niger* recorded by Gilbert, 1905 (p. 591) and 1913 (p. 100), obviously is identical with the *L. ater* described by Taaning, 1928, having the *VLO* immediately below the lateral line and the first *SAO* above the interspace between second and third *VO*: but on the other hand is not concordant with the redescription of *L. niger* rendered by Brauer, 1906 (p. 242) [see Parr, 1928, pp. 87 and 104]. Fowler, 1928 (p. 68), merely refers to Gilbert's descriptions.

n². *PLO* about midway between lateral line and the base of pectoral fin. *PVO* in an approximately vertical series. *VLO* only moderately closer to the lateral line than to the base of ventral fin, the ratio between the two distances being only about 2:3.

L. macdonaldi Good and Bean, 1895.

v². *VLO* immediately below the lateral line.

L. ater Taaning, 1928.
L. cuprarius Taaning, 1928.
L. lineatus Taaning, 1928.

The inadequacy of the original figure and description (Goode and Bean, 1895, fig. 110, pl. 29, and p. 94), makes it desirable to refigure and redescribe *L. macdonaldi* in full detail.

Total length of type specimen exclusive of caudal fin 104 mm. Proportions in per cent of the total length without caudal fin: Length of head 29. Diameter of eyes 5.8. Length of lower jaw 23. Greatest height 17. Height of caudal peduncle 10.5. Distance from snout to dorsal fin 46. Distance from snout to ventrals 43. Distance from snout to anal fin 58.

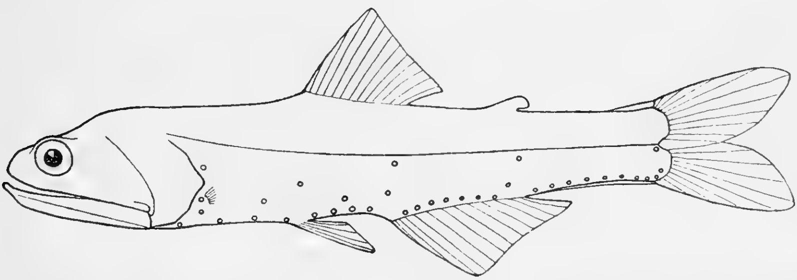

FIGURE 9.—LAMPANYCTUS MACDONALDI GOODE AND BEAN. THE NUMBER OF SEPARATE INFRA- AND SUPRA-CAUDAL LUMINOUS SCALES CAN NOT BE CLEARLY MADE OUT IN THE TYPE SPECIMEN

Snout short. Praeopercular margin strongly inclined. Ventrals somewhat in advance of the origin of dorsal fin. Origin of anal fin under the end of the anterior three-fourths of the base of dorsal fin. The comparatively great height of the caudal peduncle is conspicuous. Pectorals rudimentary.

PLO about midway between lateral line and base of *P*. *PVO* nearly vertically arranged. 5 *PO*, the fourth elevated to midway between the levels of lower and upper *PVO*. *VLO* about two-thirds as distant from the lateral line as from the base of ventral fin. 4 *VO*, all on the same level. 3 *SAO*, broadly angulate. First *SAO* above the interspace between second and third *VO*. Second *SAO* only very slightly higher, well behind the vertical from the last *VO*. Upper *SAO* close to the lateral line, on a line with the second *SAO* which passes well behind the fourth *VO*. 7 antero-anal organs, equally spaced in a gently convex curve, none ele-

vated. 2 *Pol*, the upper close to the lateral line and well behind the vertical from the lower *Pol*, which is again well behind, but not so very much higher than, the last antero-anal organ (see figure). 7 postero-anals, entirely behind the base of anal fin and confluent with the praecaudals, which have been counted as four. Ultimate *Prc* immediately below the end of the lateral line, vertically above or even very slightly in advance of the penultimate *Prc*. Interspace between ultimate and penultimate *Prc* greatly increased.

Supracaudal luminuos plates occupy only about one-third of the distance between adipose and caudal fins, while the infracaudal plates extend through almost the entire length of the caudal peduncle. The numbers of the luminous scales can not be counted.

But for the type specimen there is no reliable record of the species.

LAMPANYCTUS OMOSTIGMA Gilbert, 1908

Lampanyctus amostigma Gilbert, 1908; Jordan and Jordan, 1922; Parr, 1928, Fowler, 1928(?).

Material investigated. Type specimen No. 75769, U.S.N.M. From the Marquesas Island.

Lampanyctus omostigma has been very adequately and accurately described and figured by Gilbert, 1908 (p. 232 and pl. 5).

Correctly defined in the previously rendered key.

LAMPANYCTUS REINHARDTI Jordan, 1922

Nyctimaster reinhardti Jordan, 1922; Jordan and Jordan, 1922.
Lampanyctus omostigma (part ?), Fowler, 1928.

Material investigated. Type lot No. 84095, U.S.N.M. (2 specimens from the coast of Hawaii).

This purely nominal species is entirely without taxonomic value, being quite unidentifiable either from the types or from the original description, on account of the dried out condition of the specimens on which it has been based, and the consequent inadequacy of its diagnosis. It may be taken for granted from their general appearance that the type specimens represent some species of the genus *Lampanyctus*, but nothing is known or perceptible of the numbers and arrangement of their photophores.

Fowler, 1928 (p. 69), provisionally identifies *L. reinhardti* with *L. omostigma*. This view on the taxonomic status of the former nominal species is quite probably correct, but can neither be proved nor disproved on the basis of the above discussed type specimens; and, as the same will also hold good of any other theory that might be advanced, the author has deemed it advisable not to accept or attempt any identification at all.

LAMPANYCTUS PUNCTATISSIMUS Gilbert, 1913

L. punctatissimus GILBERT, 1913; PARR, 1928.

Material investigated. Type specimen No. 74469, U.S.N.M. Suruga Bay, Japan.

Adequately and accurately described by Gilbert, 1913, p. 103, but not formerly illustrated. The accompanying diagram has therefore been prepared from the type specimen.

VLO, upper *SAO*, *Pol* and *Prc* immediately below the lateral line.[22]

Correctly defined in the previously rendered key.

Known only from Japan.

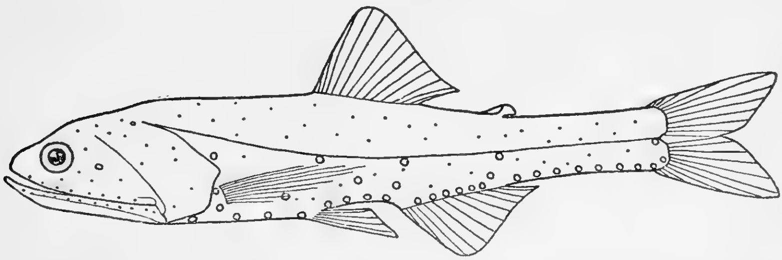

FIGURE 10.—LAMPANYCTUS PUNCTATISSIMUS GILBERT. ONLY A SMALL SELECTION OF THE MINUTE ACCESSORY PHOTOPHORES HAVE BEEN DRAWN TO SHOW THEIR RELATIVE PROPORTIONS

LAMPANYCTUS STILBIUS Gilbert, 1913

Lampanyctus stilbius GILBERT, 1913; PARR, 1928; FOWLER, 1928.

Material investigated. Type specimen. No. 757768, U.S.N.M. Marquesas Island.

Very accurately and adequately described and figured by Gilbert 1908 (p. 235 and pl. 6).

Correctly defined in the previously rendered key.

Recorded only from the type locality.

LAMPANYCTUS RITTERI Gilbert, 1915

Lampanyctus ritteri GILBERT, 1915; PARR, 1928.

Material investigated. Type specimen No. 75807, U.S.N.M. Monterey Bay, California.

Adequately described and figured by Gilbert, 1915 (p. 318 and fig. 3, pl. 15). The presence of a very minute photophore on the shoulder, mentioned by Gilbert, as a small humeral spot, in addition to a similar small photophore above the posterior corner of the mouth identifies this species with division *c* (p. 88), instead of division *d*

[22] "Near the lateral line but not in contact with it."

(p. 89), in the previously rendered key. These spots are, however, both so minute that they will probably not be recognizable in small or even moderate sized specimens, the type specimen being very large, 120 mm. without caudal fin. This particularly holds good of the photophore on the shoulder. The species will therefore probably more often be looked for in the said division *d*, in which it has previously been placed, or even in division *a* (loc. cit., p. 83). In division *c*, *L. ritteri* will be easily recognizable by the low position of its *VLO*, which is only about midway between the lateral line and the base of ventral fin, while it is situated immediately below the lateral line in the three other species of the same division (*L. punctatissimus*, *L. jordani*, and *L. stilbius*). In division, *a*, the species will seem very close to *L. macdonaldi*, as described on the preceding pages, being differentiable, however, by the higher position of its *PLO*, which is much closer to the lateral line than to the base of pectoral fin, instead of midway between as in *L. macdonaldi*, and

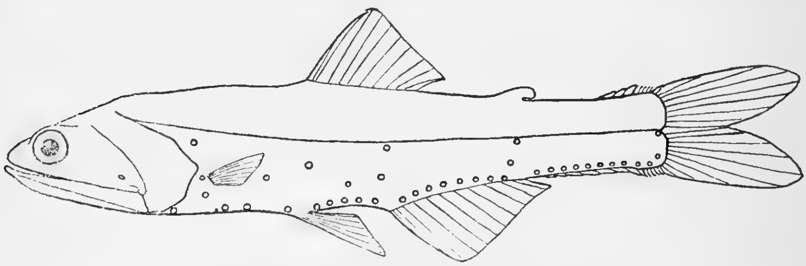

FIGURE 11.—LAMPANYCTUS REGALIS GILBERT

also by the slightly lower position of its *VLO*. The differentiation of *L. ritteri* in division *d* has been treated in the previously rendered key.

Known only from the coast of California.

LAMPANYCTUS REGALIS Gilbert, 1892

Myctophum regale GILBERT, 1892.
Nannobrachium regale JORDAN and EVERMANN, 1896.
Myctophum (Lampanyctus) regale BRAUER, 1906.
Lampanyctus regalis GILBERT, 1915; PARR, 1928.

Material investigated. Type specimen No. 44289, U.S.N.M. Coast of California.

The original diagnosis (Gilbert, 1892, p. 7) has been supplemented by a detailed, and in general very accurate description rendered by Gilbert, 1915 (p. 316), but no illustration has been previously published.

As in the case of *L. ritteri*, the "somewhat larger luminous body . . . on lower posterior portion of cheeks" is so minute that there is a considerable probability of its being unrecognizable in small

specimens. 5 *VO* were found to be present instead of only 4 as described by Gilbert.[23]

Correctly defined in the previously rendered key.

Recorded only from the coast of California.

LAMPANYCTUS ALATUS Goode and Bean

Lampanyctus alatus GOODE and BEAN, 1895; JORDAN and EVERMANN, 1896. (Not Taaning, 1918,[24] and Breder, 1927.[25])

Myctophun (*Lampanyctus*) *alatum* BRAUER, 1906; ZUGMAYER, 1911; BARNARD, 1925.

Lampanyctus pseudoalatus TAANING, 1928, PARR, 1928.

Material investigated. Type sample No. 43769, U.S.N.M. Two specimens from the Gulf of Mexico.

An inspection of the above two type specimens reveals the identity of *Lampanyctus alatus* Goode and Bean with *L. pseudoalatus* Taaning, 1928, by the presence of a luminous scale (or a pair of luminous scales) in the adipose dorsal fin as well as by the comparatively high fin counts already previously recorded by Goode and Bean (1895, p. 79). [D 13, A 17–18, as compared with D 11–13, A 14–15 in *L. pusillus* Johnson (according to Taaning, 1928, p. 66).] The *VLO*'s have, on the other hand, become completely lost in both specimens, and the organ indicated in Goode and Bean's figure (loc. cit., fig. 92, pl. 24) in what might be an approximately normal position for a *VLO*, evidently gives a somewhat misplaced representation of the elevated fourth *PO*, which is well preserved in the specimens, but otherwise not shown in the illustration. This error in the original drawing certainly has given ample justification for the introduction of Taaning's new species *L. pseudoalatus*, which, however, must now be included among the synonyms of *L. alatus* Goode and Bean, as above made out. The existing confusion in the literature makes a complete redescription and a new figure of the species desirable.

Measurements of type sample of Lampanyctus alatus Goode and Bean, 1895 No. 43769 U.S.N.M.

[In per cent of the total length without caudal fin]

Total length without caudal fin in mm	47	44
Length of head	28	27
Diameter of eyes	6.5	6.8
Length of lower jaw	21	22
Greatest height	17	17
Height of caudal peduncle	8.5	9
Snout to D	47	47
Snout to V	42	41
Snout to A	57	58

[23] The author is indebted to Messrs. B. A. Bean and E. D. Reid, of the division of fishes, United States National Museum, for kindly verifying the correctness of this observation.

[24] *L. pusillus* Johnson, according to later identification by Taaning (1928, p. 66).

[25] *Lampanyctus warmingi* Lütken, *Myctophum macrochir* Günther, and *Myctophum imitator* (Parr) [=*M. suborbitale* Gilbert].

Pectoral fins long, reaching to or beyond the origin of anal fin.

Minute luminous organs scattered over the head and body. A moderate, but conspicuous, photophore in the middle of each cheek. *PLO* close to the lateral line. 2 *PVO* in a slightly oblique series, the upper a little anterior to the lower. 5 *PO*, the fourth elevated approximately to the level of the lower end of the base of pectoral fin. *VLO* lost in the types, close to the lateral line according to Brauer 1906 and Taaning 1928. 4 *VO*, all on the same level. *SAO* angulate. Anterior SAO above the interspace between second and third *VO*, slightly but distinctly higher than second *SAO*. Second *SAO* well behind vertical from the last *VO*, which is situated entirely in advance of the line through second and third *SAO*. Upper (third) *SAO* at the lateral line. Second *SAO* approximately equidistant from third *SAO* and fourth *VO*. *AO* 7+6, none elevated. The

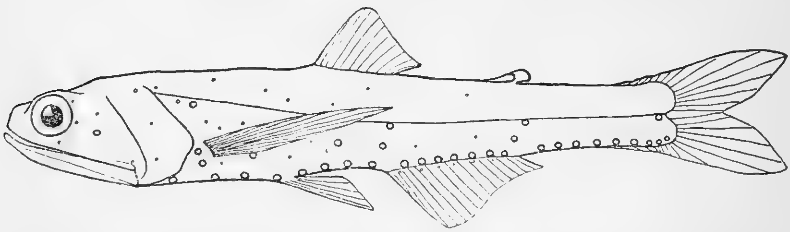

FIGURE 12.—LAMPANYCTUS ALATUS GOODE AND BEAN. ONLY A FEW OF THE MINUTE ACCESSORY PHOTOPHORES HAVE BEEN DRAWN TO SHOW THEIR RELATIVE PROPORTIONS

postero-anal series begins well behind the base of anal and is posteriorly confluent with the 4 *Prc*, which are differentiable, however, by their smaller size and the shorter intervals between the first and second and between the second and third organs. Interspace between third and fourth *Prc* greatly increased. Fourth *Prc* immediately below the lateral line, somewhat in advance of the vertical from the third *Prc*. 2 *Pol*, in a straight, oblique series with the last antero-anal photophore, and with the upper organ immediately below the lateral line, well behind the vertical from the lower.

Four supra- and four infra-caudal luminous scales, the latter occupying a somewhat greater portion (about two-fifths) of the length of the free caudal peduncle than do the former. A luminous scale, or pair of scales in the adipose fin.

The species has been recorded from the Atlantic and Indian oceans.

LAMPANYCTUS CROCODILUS Risso, 1810

Gastropelecus crocodilus Risso, 1810.
Lampanyctus crocodilus Parr, 1928 (with earlier synonymy).
Lampanyctus gemmifer Goode and Bean, 1895; Jordan and Evermann, 1896. (*Not* Brauer, 1906; Zugmayer, 1911; Pappenheim, 1914; Taaning, 1928; and Parr, 1928.)

Material investigated. Type specimen of *Lampanyctus gemmifer*, Goode and Bean, No. 35604, U. S. N. M. Western Atlantic.

An inspection of the above type specimen reveals the perfect identity of Goode and Bean's species with the *L. crocodilus* already described by Risso in 1910, as clearly shown on the accompanying diagram. Three photophores are found on each cheek, in the arrangement typical of *L. crocodilus* and a luminous scale is present in the adipose fin.

Further discussion of the characters of the specimen is unnecessary with the very adequate descriptions of *L. crocodilus* already

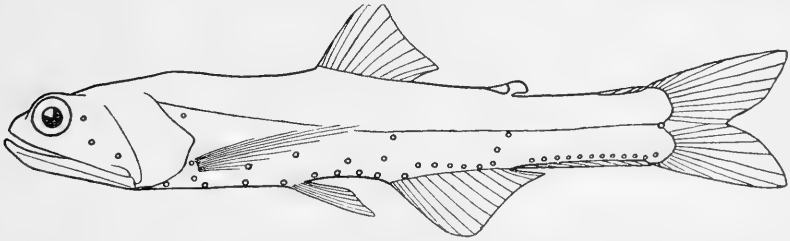

Figure 13.—Lampanyctus crocodilus Risso, drawn from the type specimen of Lampanyctus gemmifer Goode and Bean

available in the literature (Brauer, Holt and Byrne, Taaning; see synonymy in Parr, 1928, p. 90).

With *L. gemmifer* thus eliminated as a separate species, however, it now becomes necessary to designate a new name for the truly distinct taxonomic form currently identified with Goode and Bean's nominal species.

LAMPANYCTUS TAANINGI, new species

Myctophum (Lampanyctus) gemmifer Brauer, 1906; Zugmayer, 1911; Pappenheim, 1914.
Lampanyctus gemmifer Taaning, 1928; Parr, 1928.

Specimen No. 2301, of the Bingham Oceanographic Collection, "*Pawnee*" Station 25, 1927, Exuma Sound, Bahamas, has been designated as the type. A paratype from the same haul has been deposited in the United States National Museum.

The species is easily distinguished from the above *L. crocodilus* Risso by the absence of luminous scales in the adipose fin and by the presence of only two photophores on each cheek.

As a very adequate and generally accurate figure and description of the species has already previously been rendered by Brauer 1906 (p. 246), we can here confine ourselves to a few notes on minor differences observed in the above recorded type and paratype.

The upper organ on the cheeks is in both specimens slightly, but distinctly nearer to the posterior margin of the orbit than to the praeopercular margin. The posterior margin of the lower *Pol* barely touches the line through the centers of the upper *Pol* and the last *AO* anterior, these three organs thus not forming an entirely straight series, but only nearly so. The type specimen has 6+7 *AO*, well separated from the four *Prc*. In the paratype 6+8 *AO* are found, the *AO* posteriores being confluent with the 4 *Prc*. The latter organs are, however, also in this case readily distinguishable from the *AO* posteriores by their slightly smaller size and closer arrangement. Third *Prc* only very slightly, barely noticeably, below the line from the second to the fourth *Prc*. Interspace between third and fourth *Prc* increased. The above recorded numbers of *AO* differ from those given by Brauer on account of the fact that only the two most posterior *Prc* as here understood were counted as praecaudals by the said author.

Recorded only from the Atlantic.

Named in honor of Å. Vedel Taaning in recognition of his valuable contributions to our knowledge of the biology and taxonomy of the Myctophinae.

DIAPHUS UROLAMPUS Gilbert and Cramer, 1897

Myctophum (Diaphus) urolampus Brauer, 1906.
Diaphus urolampus Jordan and Jordan, 1922; Parr, 1928.

Material investigated. Type specimens No. 47709, U.S.N.M. (3 specimens).

An inspection of the type-specimens did not serve to confirm the statement rendered by Gilbert (1908, p. 227, under discussion of *D. agassizi*), that the upper antorbitals are "apparently no longer functional," but on the contrary revealed the organs in question as being, at least macroscopically, apparently perfectly equivalent with the presumably functional upper antorbitals of such species as *D. dumerili* Bleeker, *D. hypolucens* Parr and others. Each of the upper antorbitals in *D. urolampus* has a small, but very distinct body of whitish, supposedly luminous tissue imbedded in densely pigmented black tissues. There are no lower antorbitals, and no supra- or suborbital organs. The species thus properly belongs in division II A 1 in the key previously rendered by the author (Parr, 1928,

p. 115), together with *D. agassizi* Gilbert 1908,[26] but not in a separate Division I.

D. urolampus is distinct from *D. dumerili* Bleeker, in which species it was tentatively included by Weber and Beaufort, 1913,[27] in the absence of a suborbital organ, in the elevation of the first *AO* anterior and in having the *VLO* situated close to the lateral line, not at a considerable distance below it. The latter feature also distinguishes *D. urolampus* from *D. agassizi* Gilbert, with which species it is otherwise very closely related. These differences have been further made out in the following supplementary key to the species of the genus *Diaphus*, which have only one small antorbital organ on each side, entirely above the nostril (Division II A in the previously rendered key, Parr 1928, p. 115).

I. Upper *SAO* and *Pol* close to or in contact with the lateral line.
  A. *VLO* in contact with or very close to the lateral line. First *AO* anterior elevated.
   D. urolampus Gilbert and Cramer.
  B. *VLO* well below the lateral line.
   D. dumerili Bleeker.
   D. agassizi Gilbert.
   (See Parr 1928, p. 115.)
II. Upper *SAO* and *Pol* well below the lateral line.
   D. gemellari Cocco.
   D. dofleini Zugmayer.
   D. nipponensis Gilbert.
   (See Parr 1928, pp. 115–116.)

Measurements of Diaphus Urolampus Gilbert and Cramer, 1897. Type specimens No. 47709 U.S.N.M.

[In per cent of total length without caudal fin]

Total length without caudal fin in mm	90	79	75
Length of head	29	29	30
Greatest height	20	19	20
Length of lower jaw	22	22	23
Diameter of eye	7.8	8.2	8.0
Distance snout to D	42	41	42
Distance snout to V	43	42	44
Distance snout to A	64	63	65

Upper antorbital very small, but distinct and normally developed. No lower antorbital, no supra or suborbital organs. *PLO* much closer to the lateral line than to the base of pectoral fin. *PVO* in a straight series with the anterior *PO*. Fourth *PO* elevated to some-

[26] *D. dumerili* Bleeker, 1856, has for practical purposes been included both in this division and in Division IV, where it properly belongs, as the suborbital organ, though always present, is often difficult to make out on account of its minuteness.

[27] This view has been accepted by Fowler, 1928 (p. 68).

what above the level of the upper *PVO*.[28] *VLO* in contact with the lateral line. 5 *VO*. 3 *SAO*, the lower slightly in advance of the fifth *VO* and of the line through second and third *SAO*. Second *SAO* much closer to the lower *SAO* than to the upper, which is in contact with the lateral line. First *AO* anterior sharply elevated, last *AO* anterior also very conspicuously above the level of the rest of the series. *AO* 7+6. 4 *Prc*, the last organ slightly below the end of the lateral line.

The original illustration (Gilbert and Cramer, 1897, pl. 38, fig. 1) being inadequate for showing the accurate arrangement of the photophores, the accompanying diagram (fig. 14) was prepared from the type specimen.

Two specimens have a very conspicuous median dorsal luminous area on the caudal peduncle, occupying the greater part of the distance between the caudal and the adipose dorsal fin.

Known only from Hawaiian waters.

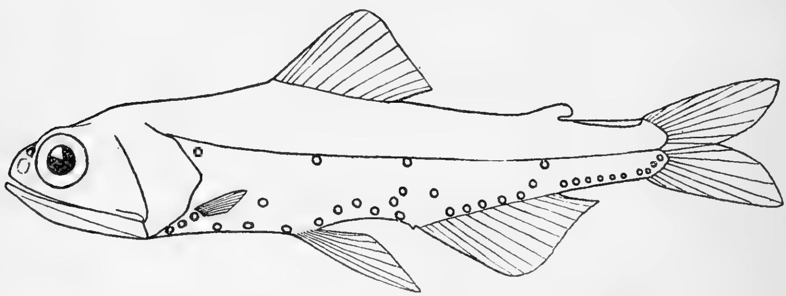

FIGURE 14.—DIAPHUS UROLAMPUS GILBERT AND CRAMER

DIAPHUS AGASSIZI Gilbert, 1908

Diaphus agassizii GILBERT, 1908 and 1913; PARR, 1928; FOWLER, 1928.
Myctophum (*Diaphus*) *lacerta* (part)? BRAUER, 1906.

Material investigated. Type specimen No. 75764, U.S.N.M. From the Marquesas Islands.

The original description and figure (Gilbert, 1908, p. 226 and pl. 2), together with the remarks upon some of its features subsequently added by the same author (Gilbert, 1913, p. 85) give a very adequate and accurate conception of the characters of this species, making further comment unnecessary.

The species is distinct from *D. dumerili* Bleeker by the absence of a suborbital organ and by the elevation of the first *AO* anterior, and from *D. urolampus* Gilbert and Cramer by having the *VLO* situated only " very slightly nearer lateral line than base of ventrals."

Properly defined in the previously rendered key (Parr, 1928, Division II A 1, p. 115).

Known from the Marquesas Islands and from Japan.

[28] This character can not be considered very reliable except in perfect specimens.

DIAPHUS DUMERILI Bleeker, 1856

Scopelus dumerili BLEEKER, 1856.
Lampanyctus lacerta GOODE and BEAN, 1895.
Diaphus nocturnus (Poey) GILBERT, 1906.
Diaphus dumerili PARR, 1928 (with earlier synonymy); FOWLER, 1928.

Material investigated. Type specimen of *Lampanyctus lacerta* Goode and Bean, 1895, No. 43778.

An inspection of the type specimen of Goode and Bean's *Lampanyctus lacerta* can only serve to confirm in every detail its perfect identity with the species now designated as *Diaphus dumerili* Bleeker according to Weber and Beaufort, 1913. (See Parr 1928, p. 126.)

D. dumerili differs from *D. agassizi* Gilbert and *D. urolampus* Gilbert and Cramer in the possession of a minute suborbital organ, which is always present, but sometimes difficult to make out. *D. dumerili* has its *VLO* situated approximately midway between the lateral line and the base of ventral fin or, more frequently, somewhat above this point.[29]

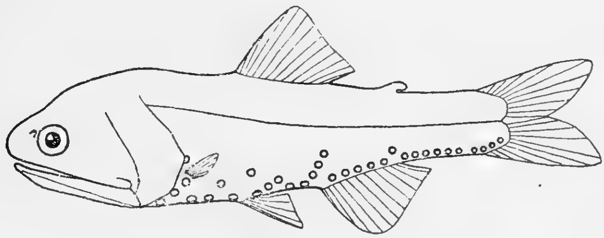

FIGURE 15.—DIAPHUS NIPPONENSIS GILBERT

The species has been very adequately described and figured by Gilbert, 1906 (p. 255 and pl. 1) under the name of "*Diaphus nocturnus* Poey," and has been further discussed in various details by Weber and Beaufort, 1913, and by Parr, 1928.

Recorded from the Atlantic and from East-Indian waters.

Taaning, 1928 (p. 58) designates the Atlantic material of *D. dumerili* as *D. dumerili nocturnus*, without discussing the differences by which this subspecies can be distinguished from the East Indian form.

DIAPHUS NIPPONENSIS Gilbert, 1913

Material investigated. Type specimen No. 74467, U.S.N.M.

This species has been adequately described by Gilbert, 1913 (p. 86), and correctly defined in the previously rendered key.

[29] This feature is not always quite reliable for the differentiation of groups 1 and 2, Division II A in the key previously given by the author (Parr, 1928, p. 115) and the main significance should therefore in this case be attached to the positions of the upper *SAO* and the *Pol* as described in the same key.

A diagram of the type specimen is rendered in the accompanying Figure 15, the species not having been previously illustrated.

Known only from Japan.

DIAPHUS GLANDULIFER Gilbert, 1913

Material investigated. Type specimen No. 74472, U.S.N.M.

Accurately and adequately described and figured by Gilbert, 1913 (p. 90 and pl. 11, fig. 2). Correctly defined in the previously rendered key.

Known only from Japan.

DIAPHUS RAFINESQUEI Cocco, 1838

Nyctophus rafinesquei Cocco, 1838.
Diaphus rafinesquei Parr, 1928 (with full synonymy).
Diaphus theta Eigenmann and Eigenmann, 1891; Goode and Bean, 1895; Jordan and Evermann, 1896; Brauer, 1906.
Myctophum protoculus Gilbert, 1891.
Diaphus nanus Gilbert, 1908 and 1913.

Material investigated. Type lot of *Diaphus theta* Eigenmann and Eigenmann, 1891, No. 41914, U.S.N.M. (2 specimens). Type specimen of *Myctophum protoculus* Gilbert, 1891, No. 44290, U.S.N.M. Type specimen of *Diaphus nanus* Gilbert, 1908, No. 75765, U.S.N.M.

The claim of *D. theta* Eigenmann and Eigenmann to specific distinctness from *D. rafinesquei* Cocco has heretofore been mainly or entirely based upon the alleged smaller size of the eyes in the type of the former nominal species. An examination of the type specimens, however, served to show that no such difference seems to exist, the eyes of *D. theta* being quite as large as those of the normal *D. rafinesquei*, with a diameter equalling more than one-third of the length of the head or 10 to 12 per cent of the total length without caudal fin. *D. theta* is therefore herewith included among the synonyms of *D. rafinesquei*.

The identity of *Myctophum protoculus* Gilbert with *D. theta* Eigenmann and Eigenmann has already been realized by the author of the former species (footnote by Gilbert in Jordan and Evermann 1896, p. 564), and could only be further confirmed by an inspection of the type.

The lack of taxonomic differences between the descriptions of *Diaphus nanus* rendered by Gilbert, 1908 and 1918, and the current descriptions of *D. rafinesquei* Cocco has already previously prompted the author to include the former name among the synonyms of the latter species (see Parr, 1928, pp. 131 and 135). This opinion stands unaltered after examination of the type specimen of *D. nanus*.

Although the three above-considered types have thus all been included in the older species *D. rafinesquei* Cocco, 1838, it is nevertheless desirable to give a more detailed account of the investigated specimens for the purpose of deciding their possible racial relationships and the taxonomic priority of their names, in case it should prove possible to subdivide the species, as here understood, into statistical groups of subordinate rank along the lines of taxonomic differentiation followed by Taaning, 1918 and 1928, by the introduction of his two new species, *D. holti* and *D. mollis*. The type specimens considered in the present paper, however, only seem to give further confirmation of the opinion already expressed by the author (Parr, 1928, pp. 131–135) that such subdivision can only be applied to comparatively restricted geographic regions, for the purpose of defining ecological races, but does not enable us to make taxonomic differentiations of general validity and therefore can not serve as a basis for the definition of separate species.

Table of measurements

[In per cent of total length without caudal fin]

Specimen No. / Type of	44290 *M. protoculus*	41914 *D. theta*		75765 *D. nanus*
Total length without caudal fin in mm	61	45	30	13
Length of head	28	27	32	33
Diameter of eye	9	10	12	12
Length of lower jaw	20	21	23	20
Length of maxillary	19	21	23	19
Greatest height	21	22	23	23
Snout to D	46	74	50	50
Snout to V	44	44	45	46
Snout to A	66	65	65	62

The arrangement of the photophores in the three types is shown in the accompanying diagram.

In *D.* "*theta*" the upper *SAO* and the *Pol* are much nearer to the lateral line than to the ventral series of photophores, while the *VLO* is considerably closer to the base of ventral fin than to the lateral line, and the *PLO* is situated about or slightly below midway between the latter and the upper end of the base of pectoral fin. The *SAO* are placed in an approximately straight and nearly equally spaced series, and the first anterior *AO* is not elevated. *AO* 5+6. *Prc* well separated from the posterior *AO*. According to the definitions first given by Taaning (1918) *D.* "*theta*" should thus agree with *D. holti* Taaning in the positions of the anterior *AO* and of the *VLO*, differing from *D. rafinesquei* Cocco in both of these respects.

According to the later synopsis by the same author (Taaning, 1928), however, we find the type of *D.* "*theta*" differing very conspicuously from *D. holti* by the higher positions of the *Pol* and the upper *SAO* in the former. It further differs from Taaning's new species *D. mollis* (Taaning, 1928) by having the *SAO* in a nearly straight series, and should thus, according to the above-mentioned

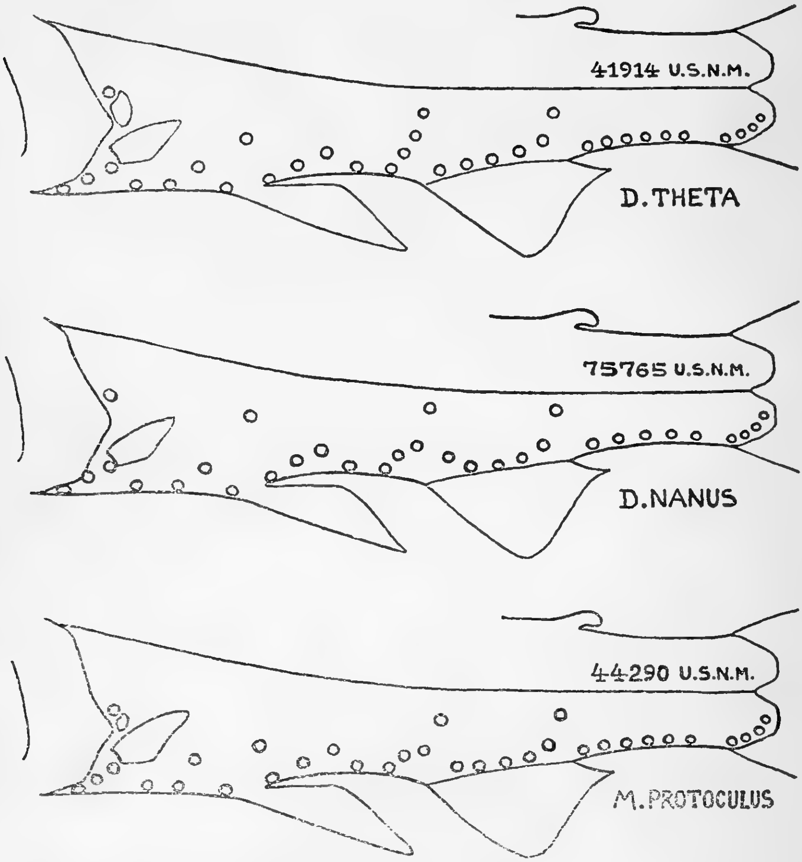

FIGURE 16.—DIAPHUS RAFINESQUEI COCCO. REPRESENTED BY THE TYPE SPECIMENS OF D. THETA EIGENMANN AND EIGENMANN, D. PROTOCULUS GILBERT, AND D. NANUS GILBERT

synopsis, be identifiable with *D. rafinesquei*, from which it has already been shown to be taxonomically different according to Taaning's definitions of 1918. It may further be mentioned that *D.* "*theta*" seems to differ from all of the above-discussed species in having 6 posterior *AO*, while the maximum recorded by Taaning for any of the forms described by him is 5 *AO* post. In most of the respects above considered *D.* "*theta*" agrees with specimen No. 2147

of the Bingham Oceanographic Collection (see Parr, 1928, pp. 131–135, and fig. 25), which differs, however, in having the *PLO* much nearer to the pectoral fin than to the lateral line, and in having the *Prc* confluent with the posterior *AO*. Specimen No. 2146 B. O. C. also shows 6 photophores in the postero-anal series and further approaches *D.* "*theta*" in having a somewhat, though not very conspicuously, increased interspace between the last *AO* posterior and the first *Prc*,[30] but also differs in the lower positions of its *PLO*, upper *SAO*, and *Pol*.[31] The discordance between the various specimens with 6 posterior *AO*, and the consequent impossibility of basing a recognition of a separate species or subspecies "*theta*" on this feature, is further increased when we also include the type specimen of *D.* "*protoculus*" in our considerations.

The type of *D.* "*protoculus*" agrees with the type of *D.* "*theta*" in having 6 posterior *AO*, well separated from the *Prc*, and in having the *VLO* nearer to the base of ventral fin than to the lateral line. It differs from *D.* "*theta*," however, in having the first anterior *AO* slightly but distinctly elevated (see the diagram), in having the *PLO*, *VLO*,[32] upper *SAO*, and the *Pol* inserted conspicuously lower than in the type of the said form, and in having the *SAO* arranged in an obtuse angle with the interspace between the second and third organ much greater than that between the first and second. According to Taaning's synopsis this species should thus seem related to *D. mollis* Taaning, but the difference from the other specimens of the *rafinesquei*-type, investigated by the author, with regard to the length of the maxillary, which is used by Taaning as a diagnostic character, is altogether too slight to be considered taxonomically significant; and it is, unfortunately, impossible to give any statements concerning the size of the luminous scale at *PLO* or the accurate positions of the suborbital organs on account of the shrinkage of

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[30] The discontinuity of the two series is shown as slightly too distinct in the diagrammatic illustration of this specimen (Parr, 1928, fig. 25), while it is very distinct and conspicuous in the type of *D.* "*theta.*"

[31] The previous statement (Parr, 1928, p. 132) that specimen No. 2146, B. O. C., agrees "fairly well" with the definition of *D. holti* Taaning in having the upper *SAO* and *Pol* "about equidistant from the lateral line and the ventral row of photophores" is based upon the vertical distance above the horizontal level of the next following organ in the ventral series (first anterior *AO* and first posterior *AO*, respectively), and is merely of relative and approximate value, being absolutely accurate only of the *Pol*, while the upper *SAO*, though distinctly lower than in specimen No. 2147, B. O. C., and much lower than in specimen No. 2148, B. O. C., is still somewhat above the point of equidistance between the two morphological levels referred to.

[32] The specimens are too small and too old to give accurate measurements, but in spite of the fact that the *VLO* is also in *D.* "*theta*" considerably closer to the ventral fins than to the lateral line, the *VLO* is still conspicuously lower in the type of *D.* "*protoculus*," as will appear from an inspection of the accompanying diagram. The same also holds good of the *PLO*, which in *D.* "*theta*" is only slightly below midway between the base of pectoral fin and the lateral line, while it is much closer to the former in *D.* "*protoculus.*"

the specimen. *D.* "*protoculus*" does in all the above considered respects, particularly with regard to the positions of upper *SAO* and *Pol*, agree very well with specimen No. 2146 B. O. C., differing however, by the arrangement of the *SAO*, which in the latter specimen are found in a gently curved, although somewhat unequally spaced series continuous with the last *VO*, not in an obtuse angle as in the type of *D.* "*protoculus*".

The type specimen of *D.* "*nanus*" differs from those of *D.* "*theta*" and "*protoculus*" in having only 5 + 5 *AO* (not 6 *AO* posteriores). According to Gilbert 1908, p. 225, the *VLO* should be "half way between lateral line and the base of ventrals"; in the author's opinion, however, they now seem distinctly closer to the lateral line. *PLO* somewhat nearer to the pectoral base than to the lateral line. Upper *SAO* and *Pol* much nearer to lateral line than to the ventral series of photophores. *SAO* in an obtuse angle. First *AO* anterior elevated nearly to the level of the second *SAO*. *Prc* well separated from the *AO* posteriores. In all these respects *D. nanus* should thus be perfectly concordant with *D. mollis* Taaning, as already suggested by Taaning when he introduced the latter species. As in the case of the specimens in the Bingham Oceanographic Collection, however, the length of the maxillaries does not show sufficient difference from the measurements of the other specimens such as for instance the type specimen of *D. protoculus* (see the table, p. 33) to make the form taxonomically recognizable as a separate species on the basis of this character.

On the basis of these observations on the type specimens of *D. theta*, *D. protoculus*, and *D nanus* the author can only feel confirmed in the opinion that the subdivision of the *rafinesquei*-like forms into entirely separate species according to the definitions rendered by Taaning (1918 and 1928) is absolutely impracticable, although such subdivision may possibly be of great value for differentiating ecological races or local subspecific forms within restricted oceanographical areas.

The accurate dimensions of the luminous scale at *PLO* and the exact natural position of the posterior suborbital organ can not now be made out with reliability in any of the above considered type specimens.

KEY TO THE SPECIES OF DIAPHUS WITH TWO SEPARATE ANTORBITAL ORGANS (ONE UPPER AND ONE LOWER) AND ONE DISTINCT SUPRAORBITAL ORGAN ON EACH SIDE

The discovery that a distinct and very well developed supraorbital organ, in addition to the upper antorbital, is present on each side not only in *D. adenomus* Gilbert, 1908, and *D. anteorbitalis* Gilbert, 1913,[33]

[33] See Parr, 1928, p. 119, key to the genus *Diaphus*, Division VI.

as already made out in the original descriptions of these species, but also in *D. chrysorhynchus*[34] Gilbert and Cramer, 1897, and *D. watasei*,[35] Jordan and Starks, 1904, makes a new key to this group of the genus *Diaphus* desirable.

I. Supraorbital organ short, triangular, entirely in advance of the vertical from the center of the eye. Upper antorbital moderate or rather large.

A. *PLO* much nearer to the lateral line than to the base of pectoral fin. Head comparatively large, its length equaling 29–31 per cent of the total length without caudal fin. Diameter of eyes 8.1–8.7 per cent of the same measurement, or about 3.4–3.6 in the length of the head. Upper *SAO* and *Pol* close below the lateral line. AO 6+5–6.
D. chrysorhynchus Gilbert and Cramer, 1897.

B. *PLO* much nearer to the base of pectoral fin than to the lateral line. Head smaller, its length only equal to about 26 per cent of the total length without caudal fin. Diameter of eyes about 6.5 per cent of the same measurement, or about 4 in the length of the head. Upper *SAO* and *Pol* more than 2 diameters below the lateral line. AO 7+5.
D. watasei Jordan and Starks, 1904.

II. Supraorbital long and slender, extending to or beyond the vertical from the center of the eye, "in the form of a narrow streak." Upper antorbital small.

A. *PLO* only very slightly below midway between the lateral line and the base of pectoral fin, its distance above the latter equaling about ⅞ of its distance below the former. Eyes about 3.8–4 in head.
D. anteorbitalis Gilbert, 1913.

B. *PLO* nearly twice as far from the lateral line as from the base of pectoral fin, the ratio between the two distances being as 16: 9. Eye about 4⅔–5 in head.
D. adenomus Gilbert, 1905.

DIAPHUS CHRYSORHYNCHUS Gilbert and Cramer, 1897

Diaphus chrysorhynchus JORDAN and JORDAN, 1922, PARR, 1928, FOWLER, 1928.
Myctophum (*Diaphus*) *chrysorhynchus* BRAUER, 1906.

Material investigated. Type sample No. 47710, U.S.N.M. (6 specimens).

The original definition and figure of this species (Gilbert and Cramer, 1897, p. 409 and pl. 38, fig. 3)[36] being in many respects inadequate for proper identification, it has been deemed advisable to render a full description and diagrammatic illustrations of the essential features observed on the type material.

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[34] See Parr, 1928, p. 120, key to the genus *Diaphus*, division 9.

[35] This species has in the previously rendered key (Parr, 1928, p. 122) been identified with *D. coeruleus* Klunzinger, according to the precedent set by Gilbert, 1913.

[36] In Gilbert and Cramer's report the figures 2 and 3 on plate 38 and the corresponding references in the text have, by misprint, become exchanged for each other, figure 2 actually representing *Myctophum fibulatum* and figure 3 *Diaphus chrysorhynchus*, while the legends and references have these species in the opposite arrangement on the plate.

Measurements of Diaphus chrysorhynchus Gilbert and Cramer

[In per cent of the total length without caudal fin]

Total length without caudal fin in mm	80	75	63
Length of head	29	31	30
Greatest height	21	21	21
Length of lower jaw	21	21	21
Diameter of eyes	8. 1	8. 7	8. 7
Snout to D	41	43	42
Snout to A	61	65	63
Snout to V	41	44	42

The description of the supraorbital organ as "a triangular or heart-shaped portion of it (the "anteorbital gland") at the antero-dorsal angle of the orbit" has proved inadequate for conveying to subsequent investigators the proper conception of the morphological status of the organ in question. This supraorbital organ is quite distinctly, although narrowly, separated from the upper antorbital by a dividing ridge running obliquely upwards and mesad in a transverse plane at the anterior end of the snout. The subraorbital thus occupies a shallow, more superior and lateral concavity of its own, while the concavity of the upper antorbital is entirely transverse and forwardly directed (compare the figs. 17 and 18). There is apparently no continuity between the luminous tissues of the upper antorbital and the supraorbital organs in any of the specimens, the very conspicuous dividing ridge appearing as a narrow, lack lustrous, black line between the highly lustrous, silvery tissues of the organs themselves. These features of the circumorbital organs in *D. chrysorhynchus* are strongly affirmative of the opinion already previously expressed by the author that the so-called upper antorbital of such forms as *D. effulgens* Goode and Bean, 1895, is not homologous with the upper antorbital organs of the other Myctophinae, but rather with the constricted supraorbital portion of the upper antorbital in *D. metopoclampus*, which is again undoubtedly homologous with the supraorbital of *D. chrysorhynchus*. A comparison between the accompanying diagram (fig. 16) and the illustration of the circumorbital organs in *D. effulgens* already previously rendered (Parr, 1928, fig. 30, no. 6, p. 140) makes this relationship quite obvious. The author therefore no longer feels any hesitation in regarding the circumorbital organs of Division IX in the key to the genus *Diaphus* (Parr, 1928, p. 120) as developed through the differentiation of a

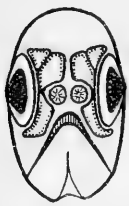

FIGURE 17.—FRONTAL VIEW OF THE HEAD OF DIAPHUS CHRYSORHYNCHUS GILBERT AND CRAMER, SHOWING THE ANTORBITAL AND SUPRAORBITAL ORGANS

separate supraorbital organ followed by a complete fusion of the upper and lower antorbitals on each side. Division IX then differs from the group treated in the key on page 37 (Division VI, Parr, 1928) by this latter feature, while the upper and lower antorbitals in the latter group, now under consideration, always remain distinct from each other.

The upper antorbitals of *D. chrysorhynchus* are quite large and only narrowly separated from each other as shown in the figure 17. The lower antorbital has a long, narrow, posterior ventral extension along the lower margin of the eye, ending approximately at the vertical from the center of the pupil or even beyond this point.

PLO conspicuously nearer to the lateral line than to the base of pectoral fin. *PVO* in a straight series with the anterior *PO*. Fourth *PO* elevated approximately to the level of the upper *PVO*. *VLO* about midway between the lateral line and the base of ventral fin.

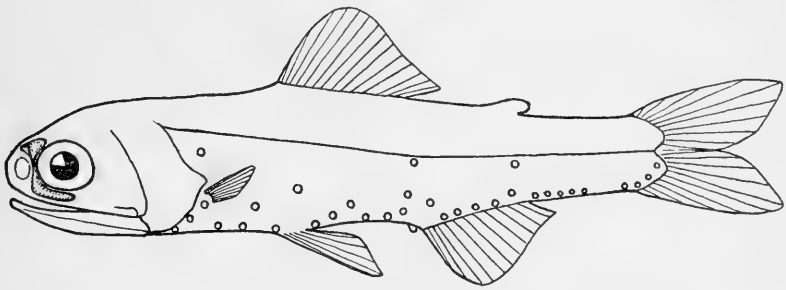

FIGURE 18.—DIAPHUS CHRYSORHYNCHUS GILBERT AND CRAMER

5 *VO*. SAO in a very steeply inclined, straight line, the continuation of which falls well behind the last *VO*. Interspace between first (lower) and second *SAO* much smaller than that between the second and the third (upper) *SAO*. 6+5 *AO* were counted in 11 cases, 6+6 *AO* in one case, each side being counted separately. First anterior *AO* elevated to a level about midway between that of the lower and that of the middle *SAO*. Last anterior *AO* also elevated. Upper *SAO* and *Pol* close to the lateral line. First posterior *AO* behind the base of anal fin. 4 *Prc*, equally spaced and curved, widely separated from the posterior *AO* and with the upper organ well below the end of the lateral line.

Known only from Hawaiian waters.

DIAPHUS WATASEI Jordan and Starks, 1904

Material investigated. Type specimen No. 51443, U.S.N.M.

This species was identified by Gilbert, 1913 (p. 95) with *D. coeruleus* Klunzinger 1871 and his example was followed by the present author in the previously rendered key to the genus *Diaphus* (Parr,

1928, p. 122). An inspection of the type specimen, however, tends to make this identity seem rather problematical on account of the fact that a well developed supraorbital organ, quite distinct from the moderate upper antorbital, apparently is to be found in the original *D. watasei.* A slight damage of the type specimen has made it impossible to make out the nature or presence of the upper organs of the circumorbital series on the left side of the head, but conditions on the right side [37] do, in the author's opinion, scarcely leave room for any doubt as to the existence of a distinct supraorbital organ, similar to the corresponding organ in *D. chrysorhynchus* in shape, nature, and position; but considerably smaller. Such supraorbital organs have not been described for *D. coeruleus*, and *D. watasei* must therefore, at least tentatively, be regarded as taxonomically distinct from the former species, although agreeing very closely in most other respects.

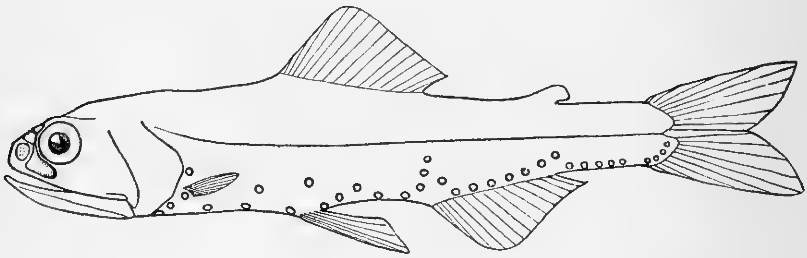

FIGURE 19.—DIAPHUS WATASEI JORDAN AND STARKS

The original illustration (Jordan and Starks, 1904, p. 581) being inadequate for showing the exact arrangement of the photophores and circumorbital organs, the accompanying diagram has been prepared from the type specimen.

PLO much nearer to the base of pectoral fin than to the lateral line. 5 *PO.* Fourth *PO* elevated approximately to the level of the upper *PVO.* *VLO* approximately midway between the lateral line and the base of ventral fin. 5 *VO.* *SAO* nearly equally spaced in a steeply inclined, straight line, the continuation of which passes well behind the last *VO.* *AO* 7+5. First anterior *AO* elevated to about midway between the levels of the first (lower) and second *SAO.* The posterior part of the antero-anal series is also gradually elevated toward the *Pol* with which the series is practically continuous. This elevation is noticeable from the fifth to the seventh antero-anal organs, inclusive (fig. 19). Upper *SAO* and *Pol* more than two of their own diameters removed from the lateral line. First postero-

[37] The organs in question are shown on the left side of the specimen in the accompanying diagram, fig. 18, to make the drawing harmonize with the other illustrations for the present report.

anal organ well behind the base of anal fin. 4 *Prc*, equally spaced in an even curve, well separated from the posterior *AO* and with the upper organ well below the end of the lateral line.

Total length without caudal fin 108 mm. Proportions in per cent of the total length without caudal fin: Length of head, 26. Diameter of eye, 6.5. Length of lower jaw, 19.5. Greatest height, 19.5. Distance from snout to dorsal fin, 42. Distance from snout to ventral fins, 44. Distance from snout to anal fin, 64.

The *VLO* of *D. coeruleus* is described as being closer to the bases of the ventral fins than to the lateral line, not about midway between as in the type of *D. watasei*, but with the possible exception of the arrangement of the photophores in the posterior part of the antero-anal series, this seems to be the only difference of any significance whatever which would appear to verify the taxonomic distinctness of the two species, above suggested as a possibility on the basis of the described observations on the circumorbital organs of *D. watasei.*

The type specimen of *D. watasei* was obtained in Sagami Bay, Japan.

DIAPHUS ANTEORBITALIS Gilbert, 1913

Diaphus anteorbitalis PARR, 1928.
Lamprossa anteorbitalis JORDAN and HUBBS, 1925.

Material investigated. Type specimen No. 74471, U.S.N.M.

This species has been very adequately and accurately described and figured by Gilbert, 1913 (p. 92 and pl. 12, fig. 1), and has been correctly defined in the previously rendered key.

The distance from the upper end of the base of pectoral fin to the PLO was found to be 3.5 mm., the distance from PLO to the lateral line canal being only 4 mm.

The type specimen apparently is a spent, the sex therefore being indeterminable without microsections.

Known only from Japan.

DIAPHUS ADENOMUS Gilbert, 1905

Diaphus adenomus JORDAN and JORDAN, 1922; PARR, 1928; FOWLER, 1928.

Material investigated. Type specimen No. 51533, U.S.N.M.

The author can not agree in the statement made by Gilbert, 1913, p. 92 (under discussion of *D. anteorbitalis*) that "in *D. adenomus*, both the superior preorbital and the extension between eye and nostril are lacking." An inspection of the type specimen on the contrary reveals the presence of a small, but quite distinct upper antorbital organ, which seems perfectly similar to the corresponding organ in *D. anteorbitalis.* The author was altogether quite incapable of dis-

covering any differences between the type specimens of these two species with regard to their circumorbital organs.

D. adenomus has otherwise been quite accurately and adequately described and figured by Gilbert, 1905 (p. 592 and pl. 68, fig. 1), and correctly defined in the previously rendered key.

The distance from the upper end of the base of pectoral fin to the PLO was found to be 4.5 mm., the distance from PLO to the lateral line canal being 8 mm.

The type specimen is a female.

The statement rendered by Fowler, 1928 (p. 68), that this species is "possibly not distinct from *D. coeruleus* (Klunzinger)" would equally well apply also to the rest of the four species mentioned in the key on page 37, if the presence or absence of a supraorbital organ should prove insignificant as a taxonomic character, or if such organ should appear to be present also in the true *D. coeruleus.* The former possibility seems rather remote, however, and the latter possibility is not indicated in either of the descriptions of *D. coeruleus* given by Klunzinger, 1871, and by Brauer, 1906.

It must on the other hand also be admitted that none of the four species would be satisfactorily differentiable from each other or from *D. coeruleus* on the basis of the photophores of the body alone, and the differences in proportions would also seem comparatively insignificant if not supplemented by differences in other respects.

D. adenomus is known only from Hawaiian waters.

DIAPHUS EFFULGENS Goode and Bean, 1895

Aethoprora effulgens Goode and Bean, 1895.
Diaphus effulgens Parr, 1928 (with full synonymy).

Material investigated. Type specimen No. 43770, U.S.N.M.

The original description of this species (Goode and Bean, 1985, p. 87) being in several aspects quite inadequate with regard to the distribution of the photophores, it has been deemed advisable to render a full account of the arrangement of these organs in the type specimen and a diagram has been prepared for convenience in interpreting the description.

The upper and lower antorbitals on each side have become fused to form a pair of very large luminous organs,[38] occupying practically

[38] See p. 38. To avoid confusion by the use of the key to the species the fused upper and lower antorbitals were in the previous treatise on these fishes designated simply as lower antorbitals, in accordance with the precedent set by Brauer, 1906, and generally followed in the later literature, although the author was already at that time strongly inclined to doubt the correctness of the homologization implied by the use of such terminology. (See Parr, 1928, p. 140.) The supraorbital organs were correspondingly designated as upper antorbitals. According to the new terminology, herewith introduced, the definition of Division IX (Parr, 1928, p. 120) should read: A small supraorbital organ on each side. Upper and lower antorbitals completely fused. The latter character then distinguishes this division from the division treated on p. 37 in the present report.

the entire snout anterior to the eyes and meeting each other at the median ethmoidal crest, as shown in the previously rendered diagram of the frontal view of this species. (Parr, 1928, fig. 30, 6, p. 140.) There is a small supraorbital organ between the upper posterior part of the fused antorbitals and the anterodorsal margin of the eye, in close contact with but quite distinct from the former organ. *PLO* nearer to the base of pectoral fin than to the lateral line. The two *PVO* in a straight series with the anterior *PO*. Fourth *PO* elevated approximately to the level of the upper *PVO*. *VLO* about midway between the lateral line and the base of ventral fin. Probably 5 *VO*, but the fourth is missing in the type specimen. Second and third *VO* elevated in a straight series with the first *VO*. 3 *SAO* in a very steep, practically straight line, the continuation of which passes well behind the last *VO*. Interspace between lower and middle *SAO* much smaller than that between the middle and upper organs. The anteroanals are arranged in an equally curved,

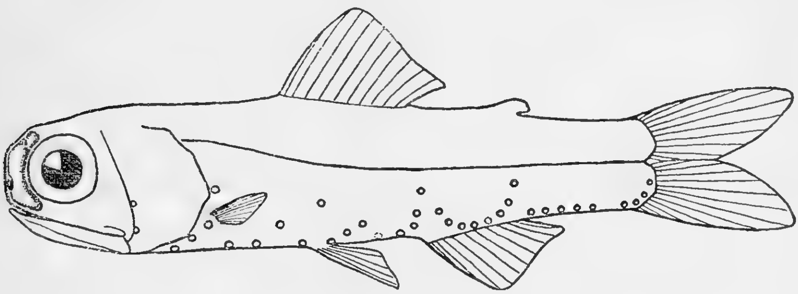

FIGURE 20.—DIAPHUS EFFULGENS GOODE AND BEAN

semicircular series which can be continued anteriorly to include the upper *SAO* and posteriorly to the *Pol*. 6 anteroanal organs are found in the type, but a somewhat increased interspace between the fourth and the fifth indicate the probability of another organ having been present in the undamaged specimen. *Pol* and upper *SAO* well below the lateral line (about two-thirds of their own diameters removed from the latter), their distances from the nearest *AO ant.* considerably larger than the interspaces between the anteroanal organs themselves. 5 posteroanals in a straight series beginning entirely behind the base of anal fin. 4 *Prc*, equally spaced and curved, with the upper organ well below the end of the lateral line.

Total length without caudal fin 118 mm. Proportions in per cent of the total length without caudal fin: Length of head 31. Diameter of eye 10.6. Length of lower jaw 19. Greatest height 23. Greatest vertical height of the snout anterior to the eyes 12. Distance from snout to ventral fin 47. Distance from snout to dorsal fin 43. Distance from snout to anal fin 65.

The great height and very characteristic outline of the steep, even slightly prominent snout has not been clearly shown in the original illustration of this species. (Goode and Bean, 1895, fig. 103, pl. 27.)

Type specimen from stomach of cod taken on Brown's bank in the Gulf of Maine.

Correctly defined in the previously rendered key.

DIAPHUS LUCIDUS Goode and Bean, 1895

Aethoprora lucida Goode and Bean, 1895.
Diaphus lucidus Parr, 1928 (with full snyonymy).

Material investigated. Type specimen No. 44084, U.S.N.M.

There is nothing to add to the discussion of this species already previously rendered by the author. (Parr, 1928, p. 141.)

Recorded only from tropical east American waters.

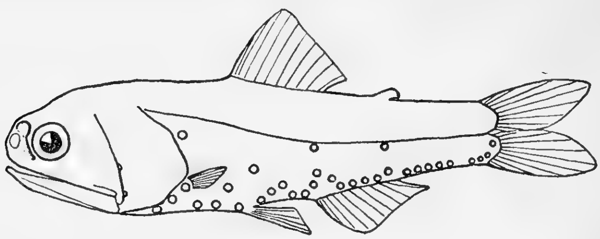

Figure 21.—Diaphus tanakae Gilbert

DIAPHUS TANAKAE Gilbert, 1913

Diaphus tanakae Parr, 1928.

Material investigated. Type specimen No. 74470, U.S.N.M.

An inspection of the type specimen brings out the fact that the antorbital organs, particularly the upper antorbitals, are proportionately so much larger in *D. tanakae* than in *D. problematicus* Parr (1928, p. 143) that the author feels satisfied that there can be no reason for maintaining any doubt about the distinctness of these two species. The upper antorbitals of *D. tanakae* are very large, extending mesad to a comparatively short distance from the median ethmoidal crest, each occupying about two-thirds or three-fourths of the distance between the latter and the anterior external margin of the orbit. The lower antorbitals extend to the level of the lower margins of the eyes.

Gilbert's description is in all other respects perfectly adequate and accurate, and the species has been properly defined in the previously rendered key.

No illustration of *D. tanakae* has heretofore been published.

Known only from Japan.

DIAPHUS SIGNATUS Gilbert, 1908

Diaphus signatus PARR, 1928, FOWLER, 1928.

Material investigated. Type specimen No. 75767, U.S.N.M.

Diaphus signatus has been adequately and accurately described and figured by Gilbert, 1908. (P. 228 and pl. 3.) Correctly defined in the previously rendered key.

Marquesas Islands.

LAMPADENA SPECULIGERA Goode and Bean, 1895

Lampadena speculigera JORDAN and EVERMANN, 1896; BRAUER, 1906; PARR, 1928.

Material investigated. Type specimen No. 43797, U.S.N.M.

The present condition of the type specimen unfortunately makes it quite impossible to determine any details of taxonomic significance, most of the photophores having become completely lost.

North Atlantic.

LIST OF ARTICLES REFERRED TO IN THE PRECEDING NOTES

For a full bibliography see Parr, 1928, pp. 180–193.

ALCOCK, A. W.

1891. On the deep-sea fishes collected by the "Investigator" in 1890–91. Ann. Mag. Nat. Hist., ser. 6, vol. 8, 1891.

BARNARD, K. H.

1925. A monograph of the marine fishes of South Africa, pt. 1. Ann. South African Mus., vol. 21, 1925.

BLEEKER, P.:

1856. Beschrijving van nieuwe of wenig bekende vischsoorten van Menado en Makassar. Act. Soc. Sci. Indo.-Neerl., vol. 1, 1856.

BRAUER, A.:

1904. Die Gattung Myctophum, Zool. Anz., vol. 28, 1904.

1906. Die Tiefsee-Fische, I, Systematischer Teil. Wiss. Ergebnisse, Deutschen Tiefsee-Exp. "Valdivia," vol. 15, Lief. 1. Jena, 1906.

BREDER, C. M.:

1927. Fishes, Sci. Res. First Oceanogr. Exp. "Pawnee," 1925. Bull. Bingham Oceanogr. Coll., vol. I, art. 1, 1927.

COCCO, A.:

1838. Su di alcuni Salmonidi del mare di Messina. Nuovi. Ann. Sci. Nat. Bologna, vol. 2, 1838.

COSTA, O. G.:

1840. Pesci della fauna napolitana con illustratione di specie nuove, vol. I. Napoli, 1840.

EIGENMANN, C. H. and EIGENMANN, R. S.:

1889. Notes from the San Diego Biological Laboratory. The fishes of Cortez Banks. West Amer. Scientist, vol. 6, no. 48. San Diego, 1889.

1891. Additions to the fauna of San Diego. Proc., Calif., Acad. Sci., ser. 2, vol. 3, pt. 1. San Francisco, 1891.

EVERMANN, B. W. and SEALE, A.:

1907. Fishes of the Philippine Islands, Bull. Bur. Fisheries, Dept. Comm. Labor, Washington, vol. 26, 1906 (1907).

FOWLER, H. W.:
1903. Description of a new lantern fish. Proc. Acad. Nat. Sci., Philadelphia, vol. 55, 1903.
1928. The fishes of Oceania. Memoirs, Bishop Museum. Honolulu, Hawaii, 1928.

GARMAN, S.:
1899. The Fishes. Rep. Expl. U. S. Fish Comm. St. "Albatross," 1891. Mem. Mus. Comp. Zoöl., Harvard Coll., Cambridge, Mass., 1899.

GILBERT, C. H.:
1891. Preliminary report on the fishes collected by the steamer "Albatross" on the Pacific coast of North America during the year 1889, Proc. U. S. Nat. Mus., vol. 13, 1890 (1891).
1892. Descriptions of thirty-four new species of fishes collected in 1888 and 1889, principally among the Santa Barbara Islands and in Gulf of California. Sci. Res. Expl. steamer "Albatross." no. XXII. Proc. U. S. Nat. Mus., vol. 14, 1891. Washington, 1892.
1895. The ichthyological collections of the steamer "Albatross" during the years 1890 and 1891. Rept. U. S. Fish Comm., 1893. Washington, 1895.
1905. The deep-sea fishes of the Hawaiian Islands. The aquatic resources of the Hawaiian Islands, pt. 2, sec. 1. Bull. U. S. Fish Comm., vol. 23, 1903. Washington, 1905.
1906. Certain Scopelids in the collection of the Museum of Comparative Zoölogy. Bull. Mus. Comp. Zoöl., Harvard Coll., Cambridge, Mass., vol. 46, no. 14, 1906.
1908. The lantern fishes. Rept. Sci. Res. Exp. Trop. Pacific "Albatross," 1899–1900, X. Mem. Mus. Comp. Zoöl., Harvard Coll., Cambridge, Mass., vol. 26, no. 6, 1908.
1911. Notes on lantern fishes from southern seas, collected by J. T. Nichols in 1906. Bull. Amer. Mus. Nat. Hist., vol. 30, art. 2, 1911.
1913. The lantern-fishes of Japan. Mem. Carnegie Mus., vol. 6, no. 2, 1913.
1915. Fishes collected by the U. S. Fisheries steamer "Albatross" in 1904, Proc. U. S. Nat. Mus., vol. 48, 1915.

GILBERT, C. H., and CRAMER, F.:
1897. Report on the fishes dredged in deep water near the Hawaiian Islands, with descriptions and figures of twenty-three new species. Proc. U. S. Nat. Mus., vol. 19, 1897.

GOODE, G. B., and BEAN, T. H.:
1895b. Oceanic ichthyology. A treatise on the deep-sea and pelagic fishes of the world. Special Bull. U. S. Nat. Mus. Washington, 1895.

GÜNTHER, A.:
1887. Report on the deep-sea fishes. Rept. Sci. Res. "Challenger," vol. 22, 1887.
1889. Report on the pelagic fishes. Rept. Sci. Res. "Challenger," vol. 31, 1889.

JORDAN, DAVID STARR.
1922. Description of deep-sea fishes from the coast of Hawaii, killed by lava flow from Mauna Loa. Proc. U. S. Nat. Mus., vol. 59, 1922.

JORDAN, DAVID STARR, and EVERMANN, B. W.
1896. The fishes of North and Middle America, vol. 1. Bull. U. S. Nat. Mus., 1896. Washington, 1896.
1903. Descriptions of new genera and species of fishes from the Hawaiian Islands. Bull. U. S. Fish Comm., vol. 22, 1902. Washington, 1903.

JORDAN, DAVID STARR, and HUBBS, C. L.
1925. Record of fishes obtained by David Starr Jordan in Japan, 1922. Mem. Carnegie Mus., vol. 10, Pittsburgh, 1925.

JORDAN, DAVID STARR, and JORDAN, ERIC K.
1922. A list of the fishes of Hawaii, with notes and descriptions of new species. Mem. Carnegie Mus., vol. 10, No. 1. 1922–1925.

JORDAN, DAVID STARR, and STARKS, EDWIN C.
1904. List of the fishes dredged by the steamer Albatross off the coast of Japan in the summer of 1900, with description of new species and a review of the Japanese Macrouridae. Bull. U. S. Fish Comm., vol. 22, 1902 (1904).

LÜTKEN, C.
1892*a*. Spolia Atlantica. Scopelini Musei Zoologici Hauniensis. Bidrag til kundskab om det aabne Havs Laxesild eller Scopeliner. Kgl. Danske Vidensk. Selsk. Skrifter, Raekke 6, Bind 7. Copenhagen, 1892.
1892*b*. Korte bidrag til nordisk Ichthyographi, VIII. Nogle nordiske Laxesild (Scopeliner). Vidensk. Meddel. Copenhagen, ser. 5, vol. 3, 1891 (1892).

PAPPENHEIM, P.
1914. Die Fische der Deutschen Südpolar-Expedition 1901–1903, II. Die Tiefseefische. Deutsche Südpolar-Expedition 1901–1903, vol. 15, Zoologie, VII. Berlin, 1914.

PARR, A. E.
1928. Deepsea fishes of the order Iniomi from the waters around the Bahama and Bermuda Islands. Sci. Res. Third Oceanogr. Exp. "Pawnee," 1927. Bull. Bingham Oceanogr. Coll., vol. 3, art. 3. 1928.

RISSO, A.
1810. Ichthyologie de Nice, ou historie naturelle des poissons du Departément des Alpes Maritimes. Paris, 1810.

TAANING, A. VEDEL.
1918. Mediterranean Scopelidae (Saurus, Aulopus, Chlorophthalmus, and Myctophum). Rept. Danish Oceanogr. Exp. 1908–10, No. 5, vol. 2 (Biology). Copenhagen, 1918.
1928. Synopsis of the Scopelids in the North Atlantic. Vidensk. Medd. Dansk Naturhist. Foren., vol. 86. Copenhagen, 1928.

WAITE, E. R.
1903. Additions to the fish-fauna of Lord Howe Island, No. 4. Rec. Australian Mus., vol. 5. Sidney, 1903.
1910. A list of the known fishes of the Kermadec and Norfolk Islands, and a comparison with those of Lord Howe Island. Trans. N. Zealand Inst., vol. 42, 1909. Wellington, 1910.

WEBER, M., and BEAUFORT, L. F.
1913. The fishes of the Indo-Australian Archipelago, vol. 2. Leiden, 1913.

ZUGMAYER, E.
1911*b*. Poissons provenant des compagnes du yacht "Princess Alice" (1901–1910). Res. Camp. Scient., Facs. 35. Monaco, 1911.

U. S. GOVERNMENT PRINTING OFFICE: 1929

REVISION OF THE TWO-WINGED FLIES OF THE GENUS COELOPA MEIGEN IN NORTH AMERICA

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The present revision has been prepared as the result of recent correspondence with Mr. J. E. Collin, of Newmarket, England, who has furnished information relating to synonomy and has also supplied the Museum with determined European specimens; from his data and the specimens it appears that the North American members of the genus have been misidentified to a large extent. Two species from the Bering Sea region, formerly considered to be identical with European forms, are here described as new.

All the species appear to breed in the kelps, and are found only on seashores where seaweeds of this group are washed up. This limits the distribution of the flies on the Atlantic side to the northern coast, with Rhode Island as the southern terminus, but on the Pacific the kelps extend much farther south, so that one species of the fly is common at least as far south as San Diego, Calif.

Genus COELOPA Meigen

Coelopa Meigen, Syst. Beschr., vol. 6, 1830, p. 8.—Haliday, Ann. Nat. Hist., vol. 2, 1839, p. 186.—Westwood, Introd. Mod. Classif. Ins., vol. 2, Synops., 1840, p. 144.—Stenhammar, Skandinaviens Copromyzinae (Kongl. Vetensk. Akad. Handl.) 1853 (1855), p. 317.—Loew, Mon. N. Amer. Dipt., vol. 1, 1862, p. 42.—Schiner, Fauna Austriaca, Diptera, vol. 2, 1864, p. 319.—Cole and Lovett, List Dipt. of Oregon (Proc. Cal. Acad. Sci., ser. 4, vol. 11) 1921, p. 320.—Williston, Manual N. Amer. Dipt., ed. 3d., 1908, p. 317.—Malloch, N. Amer. Fauna No. 46, 1923, p. 214, keys to species.

Fucomyia Haliday, Ann. Nat. Hist., vol. 2, 1839, p. 186.—Westwood, Introd. Mod. Classif. Ins., vol. 2, Synops., 1840, p. 144.

The genotypes of *Coelopa* and *Fucomyia* have been remarkably confused, owing to the misidentification of *Musca frigida* Fabricius. This was the only species included in *Coelopa* by Meigen in 1830, but Haliday in 1839 recognized that it was not the true *frigida* of Fabricius, and gave the name *pilipes* to Meigen's species, which thus attains the status of genotype and has been so accepted by Mr. Collin, although the matter has not been discussed in print.

Fucomyia had originally three species—the first was what Haliday thought to be the true *frigida* of Fabricius, which he distinguished from the *frigida* of Meigen; of the former he makes his own *gravis* 1833 a synonym. The other two species included are *simplex* and *parvula*, both new. Westwood (1840, p. 144) makes *frigida* Fabricius the genotype of *Fucomyia*. But here, again, is a misidentification of *frigida*, which is not a *Coelopa* at all, but probably a *Scatophaga* (Stenhammar, Copyromyz., 1855, p. 269). Haliday's supposed *frigida* Fabricius is disposed of by adopting *gravis* Haliday, 1833 for it, since Haliday himself indicated the synonymy. Thus *gravis* Haliday becomes the genotype of *Fucomyia*. The question is not of prime importance, since *Fucomyia* is undoubtedly a synonym of *Coelopa*. *Fucomyia* has bristly legs, while in *Coelopa* they are pilose; but this applies only to males, and is best developed in the large males, smaller ones showing much less difference, and females showing hardly a specific difference, much less a generic one.

The genus *Coelopa* is the main component of the small acalyptrate family Coelopidae, which is distinguished by the following characters in Hendel's recent key to the families of Diptera.[1]

Body depressed, postverticals well developed, convergent or crossed; prelabrum protruding; tibiae with preapical bristle on dorsal side, but with apicals only on ventral side; scutellum with a pair of erect, crossed apical bristles, curving forward; auxiliary vein complete, costa not broken or interrupted at tip of auxiliary or before it.

In *Coelopa* the face in profile is very deeply hollowed; the sides of the epistoma are bulging; the anal vein reaches the margin, but only as a fold. The mesonotum is strikingly flattened, with no bristles of considerable size except a single humeral, two notopleurals and one postalar—of these the single, large erect humeral is most distinctive. The antennae are rather small, the third joint rounded, with bare arista.

No other genus of the family occurs in North America; in our literature *Omomyia* Coquillett has been referred here, but it appears to show more affinity to the Scatophagidae.

All of the species vary greatly in size; specimens of *vanduzeei*, which are all recognizable by the hairs on the apical portion of the first vein, vary from three to seven millimeters in length. In all cases the larger are more spinose or pilose, the striking vestiture being reduced with the size until it becomes inconspicuous. On this account I have given up *parvula* as a name for our smaller New England specimens, without attempting to decide whether there is a

[1] Tierwelt Deutschlands, Jena, 1928, part 11, section 2, pp. 86–89.

valid European species to which the name may be applied. Mr. Collin, however, says that *gravis* and *parvula* always occur together, which casts doubt upon the validity of the latter.

I have omitted *Coelopa anomala* Cole [2], from Lower California, which is said to have a convex thorax instead of the flattened one which is so characteristic in the genus, and probably does not belong here. At any rate the form of the thorax will separate it.

KEY TO NORTH AMERICAN SPECIES OF COELOPA

MALES

1. First vein with a few hairs on apical part; middle tibiae pilose, the others spiny (California, Oregon) ---------- **vanduzeei** Cresson.
   First vein entirely bare ---------- 2.
2. All femora and tibiae with dense, long soft pile, like that of middle basitarsus, not at all bristly (Bering Sea) ---------- **stejnegeri**, new species.
   All femora and tibiae spiny in the larger specimens, bristly in the smaller, but in all cases the pile of the middle basitarsus is evidently much softer and more delicate than this ---------- 3.
3. Abdomen with spiny bristles not only on sides and hind margin but scattered over the disk of the last three segments (Bering Sea region). **nebularum**, new species.
   Abdomen with spiny bristles only on hind margin and sparsely on sides (North Atlantic Coast) ---------- **gravis** Haliday.

FEMALES

1. First vein with a few hairs on apical part (California and Oregon). **vanduzeei** Cresson.
   First vein entirely bare ---------- 2.
2. Legs usually blackish (North Pacific Coast) ---------- 3.
   Legs reddish yellow (North Atlantic Coast) ---------- **gravis** Haliday.
3. Cheek with dense, soft, rather short hair; arista minutely setulose under high power ---------- **stejnegeri**, new species.
   Cheek with sparser hair, which is somewhat bristly above; arista not minutely setulose ---------- **nebularum**, new species.

COELOPA GRAVIS Haliday

Coelopa gravis HALIDAY, Entomological Magazine, vol. 1, 1833, p. 167.

Coelopa frigida OSTEN SACKEN, Catalogue N. A. Dipt., 1878, p. 197 (not of Fabricius).—HAGEN, Canad. Ent., vol. 17, 1885, p. 140.—JOHNSON, List Dipt. New Eng., 1925, p. 248; Proc. Bost. Soc. N. H., vol. 38, 1925, p. 95.

Coelopa eximia STENHAMMAR, Copromyzinae, 1855, p. 318.

Coelopa nitidula OSTEN SACKEN, Catalogue N. A. Dipt., 1878, p. 197 (not of Stenhammer).

Coelopa parvula JOHNSON, List Dipt. New Eng., 1925, p. 248 (not of Haliday); Proc. Bost. Soc. N. H., vol. 38, 1925, p. 95.—STURTEVANT, Biol. Bull., vol. 50, p. 33.

I have examined 22 specimens from the New England coast—Massachusetts and Rhode Island. Johnson writes me, "They do not

[2] Proc Cal. Acad. Sci., vol. 12, 1923, p. 470.

seem to be found south of where the kelp grows. Narragansett Pier, R. I., is my most southern locality. I have seen the kelp a quivering mass of maggots and later an enormous swarm of flies." Length 3 to 6 mm., the smaller recorded as *parvula*. Seven specimens of both sexes from European seacoasts are also in the United States National Museum, determined by Collin, Bezzi, and Lundbeck, the two latter having identified it as *frigida* Fabricius.

Male.—Head and body black, the antennae, palpi, and proboscis reddish; a few reddish indistinct marks below wing on pleura; hind edges of last three segments and sides of last four yellowish red; abdomen flat, with a single row of bristles on each side and across the hind margin of each segment beyond the first or second (fewer in small specimens); front femora thickened and with stout spines, front tibiae spiny, but with some appressed pile on ventral side; front basitarsus with several stout, short erect spines below near base, the apex below with a thin, expanded rim or margin, wider on mesial side. Middle femora and tibiae spiny, the latter villous on flexor side and with several stout apical spines ventrally; middle basitarsus with long hair below and behind, and with about four stout spines curved downward on the front side. Hind femora and tibiae somewhat thickened, spiny, the latter with a few more delicate hairs on the flexor side; the yellow brush of cleaning hairs begins below the middle and extends the whole length of the first and second tarsal segments.

Female.—Abdominal segments less widely bordered with reddish yellow behind, but about the same on the sides. Front femora thickened, but with only a few stout bristles above.

COELOPA VANDUZEEI Cresson

Coelopa vanduzeei CRESSON, Ent. News, vol. 25, 1914, p. 457.—PETERSON, Ill. Biol. Mon., vol. 3, 1916, No. 2, p. 182 (numerous morphological figures).

Coelopa frigida COLE, First Rept. Laguna Lab., 1912, p. 156 (det. by Aldrich, not of Fabricius).—COLE and LOVETT, List Dipt. of Oregon, 1921, p. 320.

Easily recognized by Cresson's description and by the hairs on the first vein; I place the Cole and Lovett Oregon specimens here from the excellent figure, although otherwise it is not known from that State.

I have before me 119 specimens from the California coast—San Diego (Aldrich), Laguna Beach (Cole), Santa Barbara (Blaisdell, Aldrich); Pacific Grove (Aldrich), Santa Cruz (Cole). Adults appear to occur throughout the year, as Doctor Blaisdell sent a large shipment which he collected on January 2, 1929, at Santa Barbara. Professor Hine also sent five specimens of both sexes, which he collected on Kodiak Island, Alaska, in September, 1919.

COELOPA NEBULARUM, new species

Coelopa frigida Coquillett, Dipt. Commander Ids., 1899, p. 345 (not of Fallen, not of Fabricius); Proc. Wash. Acad. Sci., vol. 2, 1900, p. 460.—Malloch, North American Fauna, No. 46, 1923, p. 214, pl. 12, fig. 1.

Coelopa nitidula Coquillett, Proc. Wash. Acad. Sci., vol. 2, 1900, p. 460 (not of Stenhammar).

Coquillett reported the species from the Commander Islands and Kodiak Island, as *frigida*; and as I identify the specimens he also recorded a specimen from Kodiak Island as *nitidula.*

Male.—Differs from *gravis*, which is so widespread that it may well be used for comparison, principally by the character given in the key, the posterior part of the abdomen being much more bristly above and on the sides, and also less flattened.

Female.—The legs are almost invariably blackish, while in a dozen females of *gravis* they are uniformly reddish yellow.

Length, 3.5 to 6.2 mm.

Described from 15 males and 29 females, mostly from the Pribilof and Commander Islands in Bering Sea. From the former group, 19 of both sexes, including type and allotype, are from St. Paul Island (E. A. Preble, G. D. Hanna, A. G. Whitney), in 1914–1917; while 7 are from St. George Island (Hanna), June 6 and 14, 1914. From the Commander Islands (palaearctic), a male and two females (Stejneger) are from Bering Island, and a female (Barrett-Hamilton) is from Copper Island. One of the Stejneger females is from the early collecting in the eighties. A male and a female were collected by the Harriman Expedition (Kincaid) on Kodiak Island, in 1899, and a male from the same island (Hine) in 1917. Also two males and nine females from Katmai, Alaska, collected by Prof. J. S. Hine in 1917, and lent by him for study.

Type.—Male, Cat. No. 41859, U.S.N.M.

COELOPA STEJNEGERI, new species

Coelopa frigida Coquillett, Dipt. Commander Ids., 1899, p. 345 (not of Fabricius).

Coelopa eximia Malloch, N. Amer. Fauna, No. 46, 1923, p. 213, pl. 14, fig. 25 (not of Stenhammar).

Coelopa parvula Cole, Proc. Cal. Acad. Sci., vol. 11, 1921, p. 174 (not of Haliday).

Coelopa nitidula Coquillett, Dipt. Commander Ids., 1899, p. 345 (not of Haliday).

Coquillett reported the species from the Pribilof and Commander Islands as *frigida* and *nitidula;* Cole reported it from the former as *parvula;* and Malloch as *eximia.* The Commander Islands are in the palaearctic region, being on the western side of the North Pacific.

Male.—Black and rather shining; front opaque except the ocellar triangle and an upper border to the eye, all the opaque portion with erect hair of considerable length; the frontal bristles variable,

sometimes absent; cheeks with dense, long pile; arista with a few scattering minute setules under high power (35 diameters). Femora almost black, with long hair and no bristles; tibiae reddish to blackish, all with long pile, the middle ones with several apical spines on lower side, middle basitarsi also pilose, with several short, curved spines on front edge below; hind tibiae with long pile, below at tip with one longer and one shorter spine. The golden brush of hairs for cleaning are conspicuous on inner side of hind tibia on apical third, and on basitarsus. Abdomen shining black, with no bristles, but a good deal of black hair, especially posteriorly.

Female.—Pilose as in male, but the pile is shorter; front with some distinct frontals, but they seem variable; cheek with dense but rather short pile.

Length, 2.7 to 5.5 mm.

Described from nine males and eight females. The type and allotype are from St. Paul Island, Bering Sea, collected August 1, 1914, by E. A. Preble, and August 16, 1915, by G. D. Hanna. Another male and a female from the same island were collected by Hanna in 1915 and 1916, a male and female by A. G. Whitney in 1914, and another male by Preble in 1914; a male and a female from Bering Island, of the Commander group in Bering Sea (palaearctic), by Barrett-Hamilton and Dr. Leonhard Stejneger respectively, in 1897; a female from Pribilof Islands by Stejneger some years earlier, not dated; two females from Nikolaki, Bering Island, in 1895; a female frome Skagway, Alaska, June 14, 1921 (Aldrich); and a male and female from Union Bay, Vancouver Island, April 26, 1916 (Hanna). Also a male and female from Katmai, Alaska, 1917, lent by Prof. James S. Hine and collected by him.

Type.—Male, Cat. No. 41860, U.S.N.M.

Named in honor of Dr. Leonhard Stejneger, of the United States National Museum, whose interest in the life of the Bering Sea islands has been continuous for nearly half a century.

This is the nearest of all our species to the European *pilipes* Haliday, type of the genus, which also has all the legs with long pile and not bristles. It however has the abdomen opaque, the dorsocentral bristles quite appreciably developed, and the front with distinct lateral bristles in the male and not so much pile. The thin expansion of the front basitarsus below its apex is less noticeable in *stejnegeri* than in *nebularum*, but in *pilipes* it is hardly perceptible at all. The female of *stejnegeri* can be distinguished from that of *pilipes* by its more shining abdomen. In making these comparisons I am using four European specimens of *pilipes* received from Mr. Collin and two from Prof. T. D. A. Cockerell.

U. S. GOVERNMENT PRINTING OFFICE: 1929

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TWO NEW SPECIES OF TREMATODES OF THE GENUS PARAMETORCHIS FROM FUR-BEARING ANIMALS

By Emmett W. Price

Of the Zoological Division, Bureau of Animal Industry, United States Department of Agriculture

In this paper two trematodes which appear to be new species are described. These flukes belong to the family Opisthorchiidae Braun, 1901, and to the genus *Parametorchis* Skrjabin, 1913. The first of these species was forwarded to the Bureau of Animal Industry, October 13, 1927, by Dr. J. E. Shillinger, of the Bureau of Biological Survey, who collected them from the gall bladder of a silver fox from Wisconsin. For this species the name *Parametorchis intermedius* is proposed. The second species, comprising about a dozen specimens, was collected from the gall bladder of a mink by Dr. Ronald G. Law, of the Experimental Fur Farm, Kirkfield, Ontario, and forwarded to the Bureau of Animal Industry for identification on February 2, 1929. For this species the name *Parametorchis canadensis* is proposed.

The genus to which these species obviously belong was proposed by Skrjabin (1913) and is characterized as follows:

Genus PARAMETORCHIS Skrjabin, 1913

Generic diagnosis.—Flattened, moderate-sized distomes, attenuated anteriorly and rounded posteriorly. Cuticle spiny. Suckers equal in size and weakly developed; acetabulum at the border of the first and second fourth of body length. Pharynx and a smaller esophagus present. Intestinal ceca extend to posterior end of body. Testes lobed and arranged tandem in posterior half of body. Uterus rosette-shaped, in anterior half of body, surrounding the acetabulum. Vitellaria lateral of uterus, in anterior half of body, and uniting in front of uterus. Ovary lobed, cephalad of testes. Receptaculum seminis moderately large, lateral of ovary. Parasites of the gall bladder of mammals.

Type species.—*Parametorchis complexus* (Stiles and Hassall, 1894).

PARAMETORCHIS INTERMEDIUS, new species

Specific diagnosis.—Parametorchis: Body linguiform, the anterior end attenuated and posterior end rounded, 3 to 3.5 mm. long by 1 mm. wide in the region of the anterior testis. Oral sucker terminal, 155μ to 262μ long by 232μ to 278μ wide, weakly muscular. Prepharynx absent; pharynx strongly muscular, 170μ to 186μ long by 140μ wide. Esophagus very short; intestinal ceca wide and sinuous, terminating 77μ to 124μ from the posterior end of body. Acetabulum weakly developed, slightly oval transversely, 150μ long by 200μ wide, and situated about 775μ to 997μ from the anterior end. Testes deeply lobed, tandem or slightly oblique, and situated in the posterior half of body. The anterior testis is from 262μ to 310μ long by 325μ to 496μ wide and the posterior from 310μ to 500μ long by 387μ to 496μ wide. Cirrus pouch absent. Seminal vesicle slender and sinuous, and usually obscured by the convolutions of the uterus. Ovary trilobed, 108μ to 140μ long by 200μ to 260μ wide, and situated a short distance in front

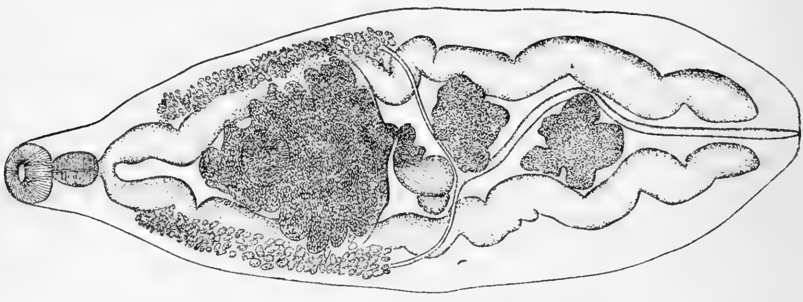

FIGURE 1.—PARAMETORCHIS INTERMEDIUS, NEW SPECIES. VENTRAL VIEW

of the anterior testis. Receptaculum seminis elongated and slightly twisted, and situated to the right and caudad of the ovary. Vitellaria lateral, extending from slightly behind the level of the esophageal bifurcation to the level of the anterior border of the ovary. Uterus composed of close transverse coils and extending from ovary to a short distance in front of acetabulum. Genital pore median, about 850μ from the anterior end of body. Excretory canal sigmoid, branching at the level of the anterior border of the anterior testis, the two branches extending extracecally to about the level of the pharynx; excretory pore terminal. Eggs oval, 30μ long by 15μ wide, and yellowish brown in color.

Host.—Silver fox (*Vulpes fulva.*)

Location.—Gall bladder.

Distribution.—United States (Wisconsin.)

Type specimens.—United States National Museum Helminthological Collection No. 27857; paratypes No. 28179.

This species apparently occupies a position intermediate between *Parametorchis complexus*, which was described by Stiles and Hassall (1894), from the gall bladder of cats from New York, Maryland, and District of Columbia, and *P. noveboracensis* which was described by Hung (1926) from the gall bladder of a cat from New York. In the former species the testes are deeply lobed and the vitellaria unite in the median line forming a U around the uterus; in the latter species the testes are almost round, the posterior being only slightly indented, and the vitellaria do not unite in front of the uterus. The peculiar character of the vitellaria in *P. complexus* appears to be constant and not changed by host relationship. Specimens of this species which the writer has examined (U. S. N. M No. 14407), collected January 21, 1907, by E. C. Stevenson from a blue fox which died in the National Zoological Park, Washington, D. C., conform in this respect to the type specimens from the cat. *P. intermedius* is considerably smaller than either *P. complexus* or *P. noveboracensis*.

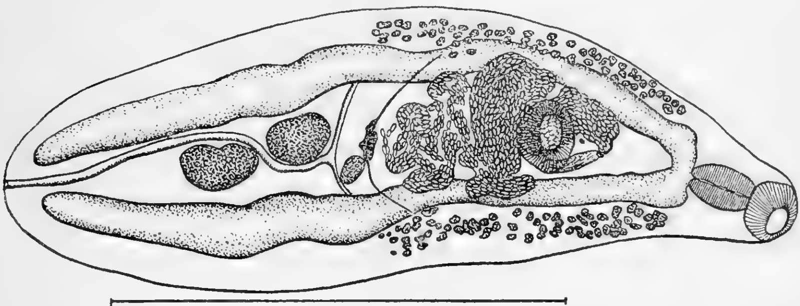

FIGURE 2.—PARAMETORCHIS CANADENSIS, NEW SPECIES. DORSAL VIEW

The body form and shape of the testes are similar to the former species, but the arrangement of the vitellaria is similar to that in the latter species. On the basis of these differences, the writer feels justified in considering *P. intermedius* a distinct species.

PARAMETORCHIS CANADENSIS, new species

Specific diagnosis.—Parametorchis: Body linguiform, transparent, 1.7 to 2 mm. long 590μ to 687μ wide in the region of the anterior testis. Cuticle missing owing to the somewhat macerated condition of the specimens. Oral sucker terminal, 93μ to 108μ long by 140u to 155u wide. Prepharynx absent; pharynx muscular, 108μ to 140μ long by 62μ to 93μ wide. Esophagus very short; intestinal ceca slightly sinuous, terminating 70μ to 90μ from the posterior end of the body. Acetabulum 125μ long by 140μ wide, weakly muscular, and situated about 470μ from the anterior end. Testes oval or slightly indented, and situated tandem in the posterior half of body; they are about equal

in size, 186μ long by 125μ wide. Cirrus pouch absent. Seminal vesicle slender and sinuous, its posterior end lying on a level with the center of the acetabulum. Ovary trilobed, small, and situated about twice its own length in front of the bifurcation of the excretory vesicle. Receptaculum seminis large and pyriform, and situated to the right and caudad of the ovary. Vitellaria lateral, extending from a short distance caudad of the esophagus bifurcation to the level of the ovary. Uterus composed of close transverse coils which are filled with small eggs. The genital pore is situated 400μ to 600μ from the anterior end of body. Excretory system similar to that in other species of the genus. Eggs oval, 22μ long by 11μ wide, and yellowish brown in color.

Host.—Mink (*Mustela vison*).

Location.—Gall bladder.

Distribution.—Canada (Kirkfield, Ontario).

Type specimens.—United States National Museum Helminthological Collection No. 28180; paratypes No. 28366.

This species is much smaller than any of the other species of the genus. It resembles *P. intermedius* in many respects but is more transparent, the testes are oval instead of being lobed, and the egg is slightly smaller. Since the specimens of both of these species are fully mature, the writer feels that in view of a lack of information in regard to the influence of different hosts on the size of trematodes of this genus, these forms should be considered as separate species.

For further comparison of the more important characters of the species of *Parametorchis*, the following table is appended.

Comparative table of characters of species of Parametorchis

	Parametorchis complexus	Parametorchis noveboracensis	Parametorchis intermedius	Parametorchis canadensis
Body form	Linguiform	Linguiform	Linguiform	Linguiform.
Size:				
Length	5 to 7 mm	6 to 6.3 mm	3 to 3.5 mm	1.7 to 2 mm.
Width	1.5 to 2 mm	2.2 to 2.6 mm	1 mm	590 to 687μ.
Oral sucker	330 to 390μ	232 to 242μ	155 to 262μ by 232 to 278μ.	93 to 108μ by 140 o 155μ.
Acetabulum	330 to 390μ		150μ by 200μ	125μ by 140μ.
Pharynx		232 to 242μ by 281 to 300μ.	170 to 186μ by 140μ	108 to 140μ by 62 to 93μ.
Ovary	Trilobed	Trilobed	Trilobed	Trilobed.
Intestinal ceca	Sinuous	Almost straight	Sinuous	Slightly sinuous.
Testes	Lobed	Almost round	Lobed	Oval or slightly lobed.
Uterus	Rosette-shaped	Rosette-shaped	Compact transverse coils.	Compact transverse coils.
Vitellaria	United in front of uterus.	Not united	Not united	Not united.
Receptaculum seminis.	Pyriform	Pyriform	Slightly twisted	Pyriform.
Egg	24μ by 12μ	28–32μ by 15–18μ	30μ by 15μ	22μ by 11μ.

REFERENCES

HUNG, SEE-LÜ.

1926. A new species of fluke, Parametorchis noveboracensis, from the cat in the United States, Proc. U. S. Nat. Mus., Wash. (2627), vol. 69, art. 1, pp. 1–2, fig. 1.

SKRJABIN, K. I.

1913. Vogeltrematoden aus Russich Turkestan, Zool. Jahrb., Jena., Abt. f. Syst., vol. 35, pp. 351–388, pls. 13–14, figs. 1–16.

STILES, CH. WARDELL; and HASSALL, ALBERT.

1894. A new species of fluke (Distoma [Dicrocoelium] complexum) found in cats in the United States, with bibliographies and diagnoses of allied forms. (Notes on parasites, 21.) Vet. Mag., Phila., vol. 1, June, pp. 413–432, pls. 1–4, figs. 1–19. [MS. dated March 2, 1893.]

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THE BRYOZOAN FAUNA OF THE GALAPAGOS ISLANDS

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AND

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INTRODUCTION

Continuing our investigations of the dredgings of the United States Fish Commission steamer *Albatross* preserved in the United States National Museum, we have recently completed the study of the material collected from a few stations in the vicinity of the Galapagos Islands. As a result we find that the bryozoa of the Galapagos afford equally interesting results as other classes of animals from this classic area. In the pursuit of these studies we have had financial assistance from the American Association for the Advancement of Science, which help is here gratefully acknowledged.

Located on the equatorial line, the bryozoan fauna of the Galapagos Islands is found to be particularly interesting to the paleontologist. The species common with the Gulf of Mexico indicate the ancient communication of the Pacific with the Atlantic and the very recent formation of the Isthmus of Panama. These species are *Acanthodesia savartii*, *Aplousina filum*, *Callopora tenuirostris*, *Callopora curvirostris*, *Cupuladria umbellata*, *Puellina innominata*, *Trypostega venusta*, *Hippoporina cleidostoma*, *Mamillopora cupula*, and *Lichenopora radiata*. None of these is known to have made the circuit of any of the continents, so that free communication between the two oceans must have existed.

Another remarkable phenomenon is the persistence in this region of archaic forms known hitherto only as fossils and in which naturally the anatomic structure was unknown. Very useful comparisons can thus be made by means of such species as *Proboscina lamellifera*, *Plagioecia subpapyracea*, *Diaperoecia* (*Reticulipora*) *mean-*

drina, *Defrancia stellata*, *Cavaria praesens*, and *Heteropora* sp. The materials collected were, unfortunately, not very numerous.

The bryozoa from the eastern side of the Pacific are still little known, so that we should not be surprised at the large number of new forms discriminated. Thus, of 53 species determined and studied, 29 are new and 4 new genera of Cheilostomata have been created. Three of the latter have a decided originality and are peculiar to the region.

Although under the influence of the southern current, which spreads even to the Sandwich Islands, we have not recognized the species common with South America. However, it is true that the bryozoan fauna of the South American continent is scarcely known. We hope that new explorations of the Galapagos Islands will furnish a larger quantity of material. Life is very active in these equatorial regions for a plancton of extraordinary richness assures the life of a great fauna as peculiar as it is varied.

The location, characteristics, and faunas of the three stations studied are as follows:

FAUNAL LISTS

Albatross Station D. 2813. Galapagos Island; 1° 21″ S; 89° 40′ 15″ W.; 40 fathoms; coral sand; April 7, 1888.

Acanthodesia savartii Savigny-Audouin, 1826.
Adeona granulata, new species.
Adeona tubulifera, new species.
Aplousina filum Jullien, 1903.
Callopora curvirostris Hincks, 1861.
Callopora tenuirostris Hincks, 1880.
Callopora verrucosa, new species.
Cavaria praesens, new species.
Chorizopora brongniarti Audouin, 1826.
Codonella granulata, new species.
Crepidacantha poissonii Savigny-Audouin, 1826.
Cupularia umbellata Defrance, 1823.
Dakaria sertata, new species.
Diaperoecia flabellata Canu and Bassler, 1923.
Diaperoecia? striatula, new species.
Diaperoecia subpapyracea, new species.
Diplonotos costulatum, new species.
Heteropora, species.
Hippomenella parvicapitata, new species.
Hippoporidra granulosa, new species.
Hippoporina cleidostoma Smitt, 1873.
Hippotrema (?) spiculifera, new species.
Holoporella hexagonalis, new species.
Holoporella quadrispinosa, new species.
Lagenipora marginata, new species.
Lichenopora radiata Savigny-Audouin, 1826.
Mamillopora cupula Smitt, 1873.

Membrendoecium claustracrassum, new species.
Microecia tubiabortiva, new species.
Micropora coriacea Esper, 1794.
Microporella gibbosula, new species.
Microporella tractabilis, new species.
Oncousoecia (*Proboscina*) *major* Johnston, 1847.
Osthimosia anatina, new species.
Pachycleithonia nigra, new species.
Plagioecia lactea Calvet, 1903, variety.
Proboscina lamellifera, new species.
Puellina innominata Couch, 1844.
Schizopodrella (*Stephanosella*) *biaperta* Michelin, 1842.
Smittina trispinosa Johnston, 1838, variety.
Trypostega venusta Norman, 1864.
Tubulipora, species.

Albatross Station D. 2815. Galapagos Islands; 1° 17′ 30″ S; 90° 30′ 15″ W.; 33.5 fathoms; gray sand with black specks; April 9, 1888.

Adeona tubulifera, new species.
Arthropoma cecili Savigny-Audouin, 1826.
Callopora tenuirostris Hincks, 1880.
Cauloramphus brunea, new species.
Cavaria praesens, new species.
Chaperia condylata, new species.
Codonella granulata, new species.
Crepidacantha poissoni Savigny-Audouin, 1826.
Defrancia stellata Reuss, 1847.
Dakaria sertata, new species.
Diaperoccia meandrina, new species.
Enantiosula manica, new species.
Hippoporina cleidostoma Smitt, 1873.
Hippotrema (?) *spiculifera*, new species.
Holoporella porosa, new species.
Holoporella quadrispinosa, new species.
Holoporella tridenticulata Busk, 1881.
Lagenipora verrucosa, new species.
Membrendoecium claustracrassum, new species.
Microporella tractabilis, new species.
Osthimosia anatina, new species.
Puellnia radiata Moll, 1803.
Schizopodrella (*Stephanosella*) *biaperta* Michelin, 1842.
Smittina reticulata MacGillivray, 1842.
Smittina trispinosa Johnston, 1838, variety.
Trypostega venusta Norman, 1864.
Tubulipora, species.
Tubulipora liliacea Harmer, 1898.

Albatross Station D. 3408. Off Galapagos Islands; 12′ 30″ N.; 90° 32′ 30″ W.; 684 fathoms; Globigerina ooze; April 3, 1891.

Diplonotos costulatum, new species.
Diplonotos striatum, new species.
Semihaswellia sulcosa, new species.

Order CHEILOSTOMATA Busk

Suborder ANASCA

Division MALACOSTEGA

Family BIFLUSTRIDAE Smitt, 1872

Genus ACANTHODESIA Canu and Bassler, 1920

ACANTHODESIA SAVARTII Savigny-Audouin, 1826

Zoological bibliography

1812. *Flustra savartii* SAVIGNY, Description de l'Egypte Polypes, pl. 10, fig. 10.
1826. *Flustra savartii* AUDOUIN, Explication sommaire des planches de Polypes de l'Egypte et de la Syrie, p. 240.
1873. *Biflustra savartii* SMITT, Floridan Bryozoa, Kongl. Svenska Vetenskaps-Akademiens Handlingar, vol. 11, p. 20, pl. 4, figs. 92–95.
1880. *Membranipora delicatula* HINCKS, Contributions toward a General History of the Marine Polyzoa, Annals and Magazine of Natural History, ser. 5, vol. 6, p. 18, pl. 11, fig. 1.
1881. *Biflustra delicatula* MACGILLIVRAY in McCoy, Prodrome Zoology of Victoria, decade 6, p. 28, pl. 37, figs. 2, 3.
1884. *Biflustra savartii* BUSK, Challenger, p. 67, pl. 14, fig. 2.
1887. *Membranipora savartii* WATERS, Bryozoa from New South Wales, North Australia, Annals and Magazine of Natural History, p. 181, pl. 4, fig. 8. (Variety.)
1909. *Membranipora savartii* WATERS, Reports on the marine biology of the Sudanese Red Sea, XII, Journal Linnean Society, London, vol. 31, p. 137, pl. 11, figs. 8–13.
1913. *Membranipora savartii* WATERS, Marine fauna of British East Africa and Zanzibar. Bryozoa Cheilostomata. Proceedings Zoological Society London, p. 486.
1914. *Membranipora savartii* OSBURN, Tortugas, Publication Carnegie Institution of Washington, No. 182, p. 1941.
1920. *Acanthodesia savartii* CANU and BASSLER, North American Early Tertiary Bryozoa, Bulletin 106, U. S. National Museum, p. 100, pl. 21, figs. 2–4. (Complementary bibliography geologic and geographic distribution.)
1923. *Acanthodesia savartii* CANU and BASSLER, North American Later Tertiary and Quaternary Bryozoa, Bulletin 125, U. S. National Museum, p. 30, pl. 11, figs. 1–3; pl. 2, figs. 2, 3; pl. 5, figs. 1–5; pl. 11, figs. 5–9 (forma *delicatula*); pl. 11, fig. 4; pl. 46, figs. 8, 9. (Study of the recent and fossil varieties.)
1928. *Acanthodesia savartii* CANU and BASSLER, Fossil and Recent Bryozoa of the Gulf of Mexico Region, Proc. U. S. National Museum, Art. 2710, p. 14, pl. 1, figs. 5, 6.
1929. *Acanthodesia savartii* CANU and BASSLER, Bryozoa of the Philippine Region, Bull. 100, vol. 9, U. S. National Museum, p. 66, pl. 1, figs. 1–5.

Our specimen is bilamellar, bifurcated, in narrow fronds with eight rows of cells. The mural rim is thick and granular. It is well represented by Figure 9 of Plate 11 of Canu and Bassler, 1923.

There are areal spicules but no serrate denticles, while in the Philippine and in the Gulf of Mexico specimens there are no spicules.

Biology.—The discovery of this equatorial species at the Galapagos confirms our preceding deductions on the recent formation of the Isthmus of Panama, in which we have discovered it with certainty as a fossil. Its geographic extension is very great, but everywhere it lives only in waters of little depth. Its presence in the fossils always reveals the vicinity of the shore. It is able to cross the great depths of the ocean only when parasitic on floating algae.

Occurrence.—Galapagos Islands, D. 2813.

Geographic distribution.—Atlantic: Gulf of Mexico and Florida (29 fathoms); Tortugas (10 fathoms) and between Florida and New Orleans (27–30 fathoms). Pacific: Sulu Sea and Celebes Sea in the Philippines (20–24 fathoms); Samboangan (10 fathoms); Australia, Queensland and Victoria, Palm Island (8–10 fathoms), and Darnley Island in Torres Strait. Indian Ocean: Zanzibar (8–10 fathoms); Sudanese Red Sea (5–30 fathoms) and Ceylon.

Plesiotypes.—Cat. No. 8469, U.S.N.M.

Family HINCKSINIDAE Canu and Bassler, 1927

Genus APLOUSINA Canu and Bassler, 1927

APLOUSINA FILUM Jullien, 1903

Plate 1, Figures 1, 2

1873. *Biflustra lacroixii* SMITT (not Audouin), Floridan Bryozoa, p. 18, pl. 4, figs. 85 to 88 (Florida, 21–97 m.).

1902. *Membranipora reticulum* CALVET (not Linnaeus), Bryozoaires marines des Cotes de Corse, Travaux de l'Institut Zoologique de Montpellier, ser. 2, mem. 12, p. 14.

1903. *Membranipora filum* JULLIEN, Bryozoaires provenant des campagnes de l'Hirondelle 1886–1888, Resultats des campagnes scientifiques accompanies par le Prince de Monaco, fasc. 23, p. 41, pl. 5, fig. 4 (Azores, 130–318 m.).

1907. *Membranipora filum* CALVET, Bryozoaires des expéditions scientifique du *Travailleur* et du *Talisman*, VIII, p. 386 (bibliography). (Cape Verde Islands, 80–180 m.; Cape Spartel, northwest of Morocco, 717 m.)

1923. *Callopora filum* CANU and BASSLER, North American Later Tertiary and Quaternary Bryozoa, Bulletin 125, U. S. National Museum, p. 42, pl. 45, fig. 5 (Pleistocene of Mount Hope, Panama).

?1898. *Membranipora capriensis* WATERS, Observations on Membraniporidae, Linnean Society's Journal, Zoology, p. 690, pl. 47, fig. 6 (Capri, Italy).

Structure.—In 1923 we interpreted badly the description of the ovicell given by Calvet in 1907 without figures. As it is easy to see on the figure of Smitt, 1873, the ovicell is really endozooecial; it is often ornamented with a small frontal cicatrix.

The opercular valve is very short and is supported on the mural rim, with a width of 0.16–0.20 mm. Smitt said also that it is small,

but he figures it isolated from the mural rim and gives it 0.18 mm. in width. It is difficult to appreciate these chitinous organs on the dry specimens. Our specimens are poorly located on their substratum and can be photographed only with difficulty. Nevertheless, in spite of their imperfections, they show great micrometric variations. We have measured *Lz*=0.60–0.73 mm. and *lz*=0.50–0.45 mm.

The figures of Jullien measure 0.80–0.64 mm. Waters for *M. capriensis* speaks of a length of 0.60–0.70 mm., and his figure indicates 0.84–0.44 mm. The mural rim is isolated and finely granulated. The small granulations are not always clearly visible; for this reason we have introduced doubtfully *Membranipora capriensis* Waters, 1898, which is figured with a smooth mural rim but in which the ovicell is clearly endozooecial.

The two small oral spines cited by Jullien are not visible on our specimens. Smitt did not figure them, so they appear inconstant and fragile.

We have not discovered this species in the dredgings made by the *Albatross* in the Gulf of Mexico, and we therefore can not confirm the observations of Smitt.

Our specimens from the Galapagos were dredged living on dead Cellepores at 40 fathoms of depth.

Biology.—" In the lowest state of development, it is a thin, glossy, yellow-white shining crust. In the zooecia, covered by their thin, translucent ectocyst, within the area, the bundle of tentacles and the *musculi retractores operculi* clearly present themselves through their black color." (Smitt.) The ectocyst of the adult zooecia easily loses its clearness.

This species has been observed on corals, on dead bryozoa (*Cellepora*, *Steganoporella*, etc.), on *Mytilus* and on fragments of dead shells. All the specimens collected to the present time appear to have lived at the depths where they were dredged. These vary from 2 to 717 meters, which reveals a great facility of adaptation to bathymetric and thermometric conditions. However, this is an equatorial or subequatorial species in which the extension toward the north does not transgress beyond the Mediterranean. We are ignorant of the causes which maintain it in these actual biologic limits.

The species was in reproduction at the Cape Verde Islands on July 27, 1883, but at the Galapagos Islands our specimens were ovicelled on April 7 to 9, 1888.

The simultaneous occurrence in the Gulf of Mexico and the Galapagos Islands and in the Quaternary of Panama indicates the ancient communication between the Pacific and the Atlantic and the recent formation of the Isthmus of Panama. The species common to these two oceans are now rather rare. At the Galapagos Islands

the great southern current has modified considerably the nature of the plancton and all the marine fauna. The simple forms indifferent to the thermic influences alone have been able to persist. This is precisely the case for *Aplousina filum.*

Occurrence.—Galapagos Islands, D. 2813.

Geographic distribution.—Eastern Atlantic: Cape Verde Islands, 80–180 meters; Azore Islands, 130–318 meters; Cape Spartel, northwest of Morocco, 717 meters. Mediterranean: Corse, littoral; Capri (?). Western Atlantic: Florida, 13–60 fathoms. Pacific: Galapagos Islands, 40 fathoms.

Plesiotypes.—Cat. No. 8470, U.S.N.M.

Genus MEMBRENDOECIUM Canu and Bassler, 1917

MEMBRENDOECIUM CLAUSTRACRASSUM, new species

Plate 1, Figures 3–7

Description.—The zoarium is multilamellar; it incrusts fragments of shells and dead gastropods. The zooecia are oval, the point above, a little enlarged at the base, elongated, distinct, separated by a deep furrow. The mural rim is a thin salient thread; the cryptocyst almost entirely surrounds the opesium; it is very much enlarged proximally and is finely granular. The opesium is elongated, oval, distally adjacent to the mural rim, finely crenulated. At the base of each zooecium there is a small triangular avicularium oriented longitudinally, the beak above. The opercular valve is small, removed from the mural rim laterally. The ovicell is endozooecial, little apparent, covered by a small chitinous band distally and a large, thick, and much chitinized opercular valve.

Measurements.—

$$\text{Opesium}\begin{cases} ho = 0.26\text{–}0.30 \text{ mm.} \\ lo = 0.16\text{–}0.18 \text{ mm.} \end{cases} \quad \text{Zooecia}\begin{cases} Lz = 0.40\text{–}0.50 \text{ mm.} \\ lz = 0.30 \text{ mm.} \end{cases}$$

Structure.—The structure of the ovicell is quite remarkable and can be seen only on the specimens preserving their ectocyst. It is a simple distal cavity covered by a chitinous band and by a large hinged operculum thicker and more chitinized than the small opercular valve of the other cells. It is therefore little visible on specimens deprived of the ectocyst, although the doubling of the small distal avicularium is often an index of its presence.

Certain zooecia have their cryptocyst perforated by a small subcircular median opesium; they are not regenerated and we are still ignorant of their anatomical structure. The ancestrula is very small; unfortunately our specimen does not show this structure very well.

On the much calcified zooecia the opesium is smaller and the cryptocyst more developed. A simple tuberosity then replaces the distal avicularium.

Affinities.—This species differs from *Membrendoecium ovatum* Canu and Bassler, of the Philippines, in its smaller zooecia and its finely crenulated opesium. It has much resemblance to *M. transversum* Canu and Bassler, 1920, of the American Midwayan and differs only in the longitudinal orientation of the small avicularia. It could perhaps be the same as *M. papillatum* Busk, 1884, of the Philippines, in which the cryptocyst is granulated and the opesium is regularly oval, but we have no other means of comparison than the incomplete figure of the author.

Biology.—The zoarium incrusts shells in many superposed lamellæ. The exterior lamella shows then false ancestrulæ which are not derived from a larva. The lamella directly in contact with the shell has zooecia less calcified and more irregular. Our specimens were in reproduction and fixation April 7, 1888.

Occurrence.—Galapagos Islands, D. 2813 and D 2815.

Cotypes.—Cat. Nos. 8471, 8472, U.S.N.M.

Family ALDERINIDAE Canu and Bassler, 1927

Genus CALLOPORA Gray, 1848

CALLOPORA TENUIROSTRIS Hincks, 1880

1918. *Membranipora tenuirostris* WATERS, Some collections of the littoral marine fauna of the Cape Verde Islands, Bryozoa, Journal Linnean Society Zoology, vol. 34, p. 9. (Bibliography, geographic distribution).

1920. *Callopora tenuirostris* CANU and BASSLER, North American Early Tertiary Bryozoa, Bulletin 106, U. S. National Museum, p. 154, pl. 29, figs. 10, 11.

1928. *Callopora tenuirostris* CANU and BASSLER, Fossil and Recent Bryozoa of the Gulf of Mexico Region, Proc. U. S. National Museum, art. 2710, p. 31, p. 3, fig. 4.

1929. *Callopora tenuirostris* CANU and BASSLER, Bryozoa of the Philippine Region, Bull. 100, vol. 9, U. S. National Museum, p. 102, pl. 3, fig. 6.

Our specimens incrust dead shells, oysters, Cellepores, *Smittina*, Nullipores, and *Cupularia* umbellata. For the greater part they are living.

Biology.—This is a species of shallow water and does not pass beyond 90 meters. The *Albatross*, however, dredged a dead specimen in the Philippines at 379 meters. It is abundant in the equatorial or subequatorial zone, although it has been observed in the temperature zone of the Pacific.

It was in reproduction on January 30, 1885, in the region of the Gulf of Mexico, and on April 7–9, 1888, in the Gallapagos Islands, and in September 18, 1918, at La Jolla, Calif.

Occurrence.—Galapagos Island, D. 2813 and D. 2815.

Geographic distribution.—Atlantic: Madeira, Cape Verde Islands (10 fathoms). Gulf of Mexico (24–65 fathoms). Mediterranean: Naples (10–40 fathoms), Capri, Rapallo, Oran (85 meters), Adriatic. Pacific: Philippines (20–140 fathoms), La Jolla, Calif., and Queen Charlotte Islands.

Cat. No. 8473 U.S.N.M.

CALLOPORA CURVIROSTRIS Hincks, 1861

1918. *Membranipora curvirostris* WATERS, Some collections of the littoral marine fauna of the Cape Verde Islands, Bryozoa, Journal Linnean Society, Zoology, vol. 34, p. 9 (bibliography).
1923. *Callopora curvirostris* CANU and BASSLER, North American Later Tertiary and Quaternary Bryozoa, Bulletin 125, U. S. National Museum, p. 42 (Guernei).
1925. *Callopora curvirostris* CANU and BASSLER, Les Bryozoaires du Maroc et de Mauritanie, Mem. de la Société des Sciences Naturelles du Maroc, No. 10, p. 14.
1928. *Callopora curvirostris* CANU and BASSLER, Fossil and Recent Bryozoa of the Gulf of Mexico region, Proc. U. S. National Museum, Art. 2710, p. 32, pl. 3, figs. 9, 10; pl. 32, figs. 8.

Our specimens incrust a shell, a dead Cellepore and a large *Smittina foliacea*. They were living and ovicelled April 7, 1888.

Biology.—This species has almost always been dredged dead and its biology is therefore difficult to determine. We had the good fortune to find our specimens had been dredged alive. The species lives in the equatorial and temperate zones at depths varying up to 231 meters. It is another indication of the ancient communication between the Atlantic and the Pacific.

Occurrence.—Galapagos Islands, D. 2813.

Geographic distribution.—Atlantic; Polperro, Great Britain, 40 fathoms; Cape Verde Islands, 10 fathoms; shores of Morocco, 110–158 meters; Gulf of Gascogny, 135 meters; Brazil, 56 meters; Habana, Gulf of Mexico, 201 fathoms; between Cuba and Yucatan, 143 fathoms. Mediterranean: Naples, Oran, Pacific; Nukatofa, Tongatabu, 20 fathoms; Hawaiian Islands 91–113 fathoms; Indian Ocean: Dwarka, Gulf of Arabia, Laccadives Islands; Adelaide, Australia; Bangam, Bengal; Singapore (26 meters).

Cat. No. 8474 U. S. N. M.

CALLIPORA VERRUCOSA, new species

Plate 1, Figure 8

Description.—The zoarium incrusts fragments of shells. The zooecia are distinct, separated by a furrow, elongate elliptical or a little oval. The mural rim is smooth, thin, salient, and regular. The form of the opesium is that of the zooecium. The ovicell is hyperstomial, globular. In all the interopesial spaces there is a

small triangular avicularium with rounded beak. In the marginal zone of the colony, in the separating furrows of the cells, there are small elliptical zooeciules perforated by a submedian pore. On the margin itself, the zooeciules develop exclusively and arrest the formation of the normal zooecia.

Measurements.—

Opesium $\begin{cases} ho=0.40 \text{ mm.} \\ lo=0.25 \text{ mm.} \end{cases}$ Zooecium $\begin{cases} Lz=0.50 \text{ mm.} \\ lz=0.30\text{–}0.35 \text{ mm.} \end{cases}$

Affinities.—The function of the small zooeciules is absolutely unknown. They have been observed in several species; in *Mystriopora areolata* Canu and Bassler, 1923, from the Pleistocene of California, in *Callopora pumicosa* Canu and Bassler, 1928, recent species from the Gulf of Mexico, and in *Electra distefanoi*, Cipolla, 1923, of the Sicilian of Italy. They appear to have a small polypide since they undergo the phenomenon of total regeneration. Our photographs show several examples. Adventitious zooeciules somewhat more elongated in form have also been observed in other genera of the bryozoa.

Occurrence.—Galapagos Islands, D. 2813.

Holotype.—Cat. No. 8475, U. S. N. M.

Genus CAULORAMPHUS Norman, 1903

CAULORAMPHUS BRUNEA, new species

Plate 1, Figures 9, 10

Description.—The zoarium incrusts dead Cellepores. The zooecia are distinct, elongated, separated by a very deep furrow, somewhat oval. The mural rim is thick, rounded, very salient. It bears 4 distal spines and 7–9 pairs of brown, areal spines. The pedunculate avicularia are white, a little longer than the spines. The ancestrula is a very small ordinary zooecium.

Measurements.—

Opesium $\begin{cases} ho=0.30 \text{ mm.} \\ lo=0.15 \text{ mm.} \end{cases}$ Zooecium $\begin{cases} Lz=0.40\text{–}0.45 \text{ mm.} \\ lz=0.30 \text{ mm.} \end{cases}$

Affinities.—This species is very well characterized by the brown spines. They are white in *Cauloramphus spinifer* Johnston, 1847, which is the closest species.

Biology.—This is a sordid species for the living specimens, in spite of their large number of spines are always covered with calcareous granules, siliceous particles, fragments of sponges, and of dirt. It is difficult to find a specimen that can be photographed. By boiling in Javelle water the cells when completely freed from their spines and all the dirt have on the contrary a most agreeable aspect and resemble little crowns.

Occurrence.—Galapagos Islands, D. 2815.
Cotypes.—Cat. No. 8476, U.S.N.M.

Division COILOSTEGA Levinsen, 1909

Family OPESIULIDAE Jullien, 1888

Genus MICROPORA Gray, 1848

MICROPORA CORIACEA Esper, 1794

1920. *Micropora coriacea* CANU and BASSLER, Monograph Early Tertiary Bryozoa of North America, Bulletin 106 U. S. National Museum, p. 235, pl. 4, figs. 20–22. (Bibliography, geographic and geologic distributions).
1921. *Micropora coriacea* MARCUS, Bryozoen von den Juan-Fernandez Inseln in Skollsberg, The Natural History of Juan Fernandez and Easter Isles, vol. 3, p. 101, fig. 4.
1923. *Micropora coriacea* CANU and BASSLER, North American Later Tertiary and Quaternary Bryozoa, Bulletin 125, U. S. National Museum, p. 58.
1928. *Micropora coriacea* CANU and BASSLER, Fossil and Recent Bryozoa of the Gulf of Mexico Region, Proc. U. S. National Museum, vol. 72, p. 62, text, fig. 8c.

Measurements.—

$$\text{Apertura}\begin{cases} ha = 0.06 \text{ mm.} \\ la = 0.10 \text{ mm.} \end{cases} \quad \text{Zooecium}\begin{cases} Lz = 0.46 - 0.50 \text{ mm.} \\ lz = 0.24 - 0.30 \text{ mm.} \end{cases}$$

A single dead specimen has been found; it has some transverse cells. This is the single species of the fauna from Juan Fernandez Island which has been drifted by the southern current as far as the Galapagos Islands. The *Albatross* also dredged it in the Hawaiian Islands.

Occurrence.—Galapagos Islands, D. 2813.
Cat. No. 8477, U.S.N.M.

Family CALPENSIIDAE Canu and Bassler, 1923

Genus CUPULARIA Lamouroux, 1821

CUPULARIA UMBELLATA Defrance, 1823

1923. *Cupularia umbellata* CANU and BASSLER, North American Later Tertiary and Quaternary Bryozoa, Bulletin 125, U. S. National Museum, p. 80, pl. 2, figs. 15–19. (Bibliography, geologic distribution.)
1928. *Cupularia umbellata* CANU and BASSLER, Fossil and Recent Bryozoa of the Gulf of Mexico Region, Proc. U. S. National Museum, Art. 2710, p. 64, pl. 1, figs. 1–3.
1929. *Cupularia umbellata* CANU and BASSLER, Bryozoa of the Philippine Region, Bull. 100; vol. 9, U. S. National Museum, p. 142, pl. 15, figs. 5–11.

Variations.—The specimens collected are numerous and more vigorous than the specimens from Hawaii dredged at 4,411 meters depth.

In the great abyssal depths the bryozoa generally appear to be stunted.

At the center there is no visible ancestrula, but there are four zooecia in a cross. Each cell is perforated by six large opesiules. On the inner side the ribs are smooth when the colony is little calcified; they are granulated on the much calcified colonies.

All of our colonies were dead except one which had preserved its avicularian setae.

There exists a small variation *conica*, in which the colony is very small, full, and conical. It has been found in the Helvetian faunas of Touraine.

Biology.—This species has been dredged at very great depths, for it is one of the rare species characteristic of the abyssal ooze. Because of its mobility it can live upon the moving bottom. The bathymetric dispersion rises only up to a depth of 80 meters and it can not adapt itself easily to slight depths (Calvet, 1907). This statement of Calvet on the bathymetric dispersion is a little exaggerated, for it lives perfectly in waters of little depths, because Smitt discovered it at Cape Fear River at a depth of only 11 meters.

As it is very abundant between America and the Hawaiian Islands at the great depth of 4,411 meters with a temperature of 1.4° C. we may suppose it can exist in the boreal zone, but it is a species of the tropical zone and does not generally extend far from the Tropics. Neither the depth nor the temperature seem to modify its biologic limits.

Its locomotion facilities are much reduced and it is not able to

Occurrence.—Galapagos Islands, D. 2815; Hawaii, D. 3813.

Geographic distribution.—Mediterranean: Oran, 87 meters. Atlantic: Cape Verde Islands, 1,900 meters; Canary Islands, 80 meters; Madeira, 81–113 meters; Florida, 29 fathoms; Tortugas, 12–22 fathoms; Beaufort, N. C.; Cape Fear River, 7 fathoms. Indian Ocean: Mergui Archipelago. Pacific Ocean: Between California and the Hawaiian Islands, 2,723 fathoms.

Cat. No. 8478, U.S.N.M.

Suborder ASCOPHORA Levinsen, 1909

Family COSTULAE Jullien, 1888

Genus PUELLINA Jullien, 1886

PUELLINA RADIATA Moll, 1803

1920. *Puellina radiata* Canu and Bassler, North American Early Tertiary Bryozoa, Bulletin 106, U. S. National Museum, p. 295, pl. 41, figs. 14–18. (Bibliography, geographic and geologic distribution.)
1925. *Puellina radiata* Canu and Bassler, Les Bryozoaires du Maroc, Mémoires de la Société des Sciences naturelles du Maroc, vol. 10, p. 21.
1928. *Puellina innominata* Canu and Bassler, Fossil and Recent Bryozoa of the Gulf of Mexico Region, Proc. U. S. National Museum, Art. 2710, p. 73, pl. 10, fig. 11.
1929. *Puellina radiata* Canu and Bassler, Bryozoa of the Philippine Region, Bull. 100, vol. 9, U. S. National Museum, p. 238, pl. 22, fig. 1.

Our specimens were dead and incrusting Cellepores. They are of small dimensions.

Occurrence.—Galapagos Islands, D. 2815; Hawaii, D. 3813.

Cat. No. 8479, U.S.N.M.

PUELLINA INNOMINATA Couch, 1844

1925. *Puellina innominata* Canu and Bassler, Les Bryozoaires du Maroc. Mémoires de la Société des Sciences naturelles du Maroc, vol. 10, p. 21.
1928. *Puellina innominata* Canu and Bassler, Fossil and Recent Bryozoa of the Gulf of Mexico Region, Proc. U. S. National Museum, Art. 2710, p. 73, pl. 14, fig. 2.

The frontal pore is very constant on our specimens, which were almost all living and ovicelled. They incrust Cellepores and shells. One of them is incrusted by small Serpulas against which it could not defend itself. Reproduction occurred on April 7, 1888.

Occurrence.—Galapagos Islands, D. 2813.

Cat. No. 8480, U.S.N.M.

Family HIPPOTHOIDAE Levinsen, 1909

Genus CHORIZOPORA Hincks, 1880

CHORIZOPORA BRONGNIARTI Audouin, 1826

1925. *Chorizopora brongniarti* CANU and BASSLER, Les Byrozoaires du Maroc, Mémoires de la Société des Sciences naturelles du Maroc, vol. 10, p. 23, pl. 7, fig. 2.

A single living ovicelled specimen on *Lithothamnion* (April 17, 1888).

Occurrence.—Galapagos Islands, D. 2813.

Cat. No. 8482, U.S.N.M.

Genus TRYPOSTEGA Levinsen, 1909

TRYPOSTEGA VENUSTA Norman, 1864

1920. *Trypostega venusta* CANU and BASSLER, Bull. 106 U. S. National Museum, p. 330, pl. 85, fig. 15–16. (Bibliography, geographic distribution.)

1928. *Trypostega venusta* CANU and BASSLER, Fossil and Recent Bryozoa of the Gulf of Mexico Region, Proc. U. S. National Museum, vol. 72, art. 14, p. 77, pl. 8, figs. 5, 6.

1929. *Trypostega venusta* CANU and BASSLER, Bryozoa of the Philippines, Bull. 100, U. S. National Museum, p. 248, pl. 22, figs. 9–11.

The ovicelled zooecia not having frontal tuberosities show that our specimens belong to the form *striatula* Smitt, 1873, just as in the Philippines and in the Indian Ocean.

Biology.—Our specimens were living and ovicelled and were therefore in reproduction April 7–9, 1888. We have stated in our work on the Gulf of Mexico that reproduction occurred from January to March, which must now be changed to April.

Our specimens incrust shells and nullipores as in Europe these being the most habitual substrata of this species. Nevertheless we have observed rare colonies on bryozoa, (*Steganoporella*, *Stylopoma*), corals, and hydroids in the Gulf of Mexico and on small pebbles in the Philippines.

The geographic extension of this species is rather great. It appears more abundant in the equatorial zone, but it extends in the Atlantic up to the fiftieth parallel. The localities in the temperate zone are very rare and not yet been dredged in the Mediterranean. Perhaps it has been brought to the English Channel only by a current from the Gulf stream.

The geographic distribution which we gave in 1920 was incomplete, and we believe it useful to give it anew, adding some bathymetric notes.

Occurrence.—Galapagos Islands, D. 2813 and D. 2815.

Geographic distribution.—Eastern Atlantic: Guernsey, 16 meters, and the shores of Calvados, France, in the English Channel; Ma-

deira, in shallow water; Cape Verde Island, 110–180 meters. Western Atlantic: Beaufort, South Carolina; Tortugas, 8–24 meters; Gulf of Mexico at Habana, 98–325 meters and Florida, 41–97 meters. Indian Ocean: Amirante, 37–137 meters; Saya de Malha, 47–202 meters; Wasin, British East Africa, 16 meters; Mauritius; Tizard Banks, China Sea, 43 meters. Pacific: Philippines at Jolo, Sulu Sea, 30 meters, in the Celebes Sea, 372 meters and 11.6° C. and at Anima Solo, 170 meters and 17.2° C. (specimens all dead); Murray Islands, Torres Strait, 24–32 meters; Port Phillips Heads, Australia; Sifu, Loyalty Islands; Galapagos Islands, 54–65 meters.

Cat. No. 8471, U.S.N.M.

Family GALEOPSIDAE Jullien, 1903

Genus SEMIHASWELLIA Canu and Bassler, 1917

SEMIHASWELLIA SULCOSA, new species

Plate 10, Figures 4–8

Description.—The zoarium is free, branching dichotomously at intervals usually of 5 to 7 mm. The zooecia are indistinct, gigantic; the frontal is formed by a very thick epitheca ornamented with very deep longitudinal sulci at the bottom of which are large vacuoles rather close together. The peristome is long, cylindrical, salient, oblique. The peristome is thick, sharp edged, orbicular. The aperture is buried at the bottom of the peristomie. The ascopore is tubular, salient, oriented toward the proximal zooecium. A small orbicular avicularium (?) appears sporadically on the frontal in the vicinity of the peristomie of an adjacent zooecium. On the dorsal of the colony there are deep longitudinal sulci with large vacuoles rather close together. Small orbicular avicularia replace the vacuoles about the level of the peristomes of the cellular face.

Measurements.—

Zooecia $\begin{cases} Lz = 2.75 \text{ mm.} \\ lz = 1.00 \text{ mm.} \end{cases}$ Peristome $\begin{cases} hp = 0.45 \text{ mm.} \\ lp = 0.45 \text{ mm.} \end{cases}$

Affinities.—This species differs from the genotype *Semihaswellia proboscidea* Waters, 1889, from St. Thomas (West Indies), in its smaller peristomes and in the presence of deep longitudinal sulci arranged on both sides of the colony. The dimensions of the fossil species (Jacksonian) collected in America are much smaller than those of the two known recent species of the genus. The discovery of the genus *Semihaswellia* in the Pacific is very interesting.

Occurrence.—Galapagos Islands, D. 3408.

Holotype.—Cat. No. 8536, U.S.N.M.

Family ESCHARELLIDAE Levinsen, 1909

Genus ARTHROPOMA Levinsen, 1909

ARTHROPOMA CECILI Savigny-Audouin, 1826

1925. *Arthropoma cecili* CANU and BASSLER, Les Bryozoaires du Maroc et de Mauritanie, Mémoires de la Société des Sciences naturelles du Maroc, vol. 10, p. 23. (Biology.)
1929. *Arthropoma cecili* CANU and BASSLER, Bryozoa of the Philippine Region, Bull. 100, vol. 9, U. S. National Museum, p. 296, pl. 32, fig. 1.

A single living ovicelled specimen on a Cellepore, dredged April 9, 1888. At La Jolla, Calif., we have observed specimens ovicelled on Sept. 18, 1918.

Occurrence.—Galapagos Islands, D. 2815. La Jolla, Calif.

Cat. No. 8484, U.S.N.M.

Genus SCHIZOPODRELLA Canu and Bassler, 1917

SCHIZOPODRELLA (STEPHANOSELLA) BIAPERTA Michelin, 1842

Plate 2, Figures 1, 2

1923. *Stephanosella biaperta* CANU and BASSLER, North American Later Tertiary and Quaternary Bryozoa, Bull. 125 U. S. National Museum, p. 99, pl. 16, figs. 4–9. (Bibliography, geologic and geographic distribution.)
1925. *Stephanosella biaperta* CANU and BASSLER, Les Bryozoaires du Maroc et de Mauritanie, Mémoires de la Société des Sciences naturelles du Maroc, vol. 10, p. 30, pl. 7, fig. 5 (operculum).

Measurements.—

Apertura $\begin{cases} ha=0.10\text{–}0.12 \text{ mm.} \\ la=0.08\text{–}0.10 \text{ mm.} \end{cases}$ Zooecium $\begin{cases} Lz=0.40\text{–}0.50 \text{ mm.} \\ lz=0.34 \text{ mm.} \end{cases}$

Affinities.—The small oral avicularia are triangular and the tremopores are rather large. These are the noticeable differences from the European specimens. The ovicelled zooecia are also much better oriented, but they have the same cribriform frontal area. The affinities are essentially with the fossils from the California Pleistocene figured by Canu and Bassler, 1923 (more exactly with their figures 4–8). In tangential section the tremopores appear very small.

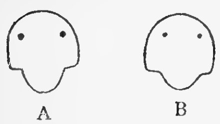


FIGURE 1. — SCHIZOPODRELLA (STEPHANOSELLA) BIAPERTA MICHELIN, 1842. TWO OPERCULA, × 85

The number of distal spines varies from 6 to 8. The operculum is the same as in typical *Schizopodrella*. Also as the ovicellarian area does not correspond to any evident or known function there is no need to maintain the genus *Stephanosella*.

The genotype itself, a fossil of the French Miocene has a smooth frontal. In our mind, the specimens of the genus *Stephanosella* were provided with a olocystal frontal, but it is indeed true that this appearance is only the result of an alteration in the fossils. It is also

true that the Miocene species is still represented in the recent seas by specimens with a tremocystal frontal. Our genus *Stephanosella* has no further reason for existence and should be suppressed. It might be preserved as an artificial subgenus for the group of species ornamented with an ovicellarian area.

Biology.—All of our specimens were living and generally ovicelled. They incrust the fragments of shells in two or many superposed lamellae. The formation of the superior lamellae is occasioned by the development of adventitious colonies arising from larvae affixed to the colony itself. These small, new, orbicular colonies suppress the ancient ones. The vitality of this species is such that the colony is sometimes 5 square centimeters in extent and sometimes entirely incloses the shells and débris. Here are, then, two extremely rare anomalies in the bryozoa. Usually a colony drives the larva far away. Generally also a single side of the shell is incrusted. However, if the latter is fixed to floating algae, we can conceive its complete envelopment, but then such colonies do not have any bathymetric significance. In 1925 (p. 30) we have shown that the bathymetric data of this species should be revised.

Our specimens were in reproduction April 7–9, 1888. Those collected by the Vanneau on the shores of Morocco were in reproduction July 26, 1923.

Occurrence.—Galapagos Islands, D. 2813 and D. 2815.

Plesiotypes.—Cat. Nos. 8485, 8486 U.S.N.M.

Genus DAKARIA Jullien, 1903

DAKARIA SERTATA, new species

Plate 2, Figures 3–6

Description.—The zoarium incrusts *Lithothamnion* and Cellepores. The zooecia are distinct, separated by a deep furrow, elongated and elliptical. The frontal is very convex and formed by a granular tremocyst with small pores. The apertura is large, suborbicular with a broad proximal, shallow sinus; the peristome is salient, thin distally, very much enlarged and festooned in its proximal part. The ovicell is large, buried in the distal zooecium, very globular, and of the same nature as the frontal, closed by the operculum with a marginated orifice.

Measurements.—

Apertura $\begin{cases} ha=0.14\text{–}0.16 \text{ mm.} \\ la=0.16 \text{ mm.} \end{cases}$ Zooecium $\begin{cases} Lz=0.60 \text{ mm.} \\ lz=0.30\text{–}0.40 \text{ mm.} \end{cases}$

Affinities.—The genus *Dakaria* is still poorly known. It was formed by Jullien in 1903 for the species in which the young orifice

has two lips juxtaposed at their extremities, the extremities of the anter included between those of the poster. The genotype has never been rediscovered alive. Canu and Bassler, 1920, have extended its limits to all the *Schizoporellas* in which the hyperstomial ovicell is closed by the operculum and in which the frontal is a tremocyst. Unfortunately their text figure was erroneous in consequence of a poor interpretation of certain published figures.

Dakaria sertata rigorously agrees with their definition and can take the place of the genotype in which the ovicell and operculum are unknown.

The operculum is white, rather thick; its proximal border is triangular and of a different form from that of the apertura. It is surrounded by a thick band like that in *Lepralia montferrandi* Audouin, 1826, figured by Waters, 1909, which is classed in the group we have called *Codonella*. This form of operculum is peculiar enough to justify the formation of a special genus if that of the genotype was not identical. *Schizoporella brunescens* Ortmann, 1890, from Japan, seems to us to belong to the same group, but its peristome is not festooned.

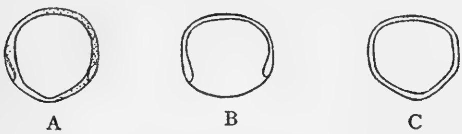


FIGURE 2.—DAKARIA SERTATA, NEW SPECIES. THREE FORMS OF OPERCULA, × 85

This species differs from *Codonella granulata*, new species which is very similar in general aspect in the absolute absence of avicularia.

Biology.—Almost all of our specimens were living and ovicelled. The species was in reproduction April 7–9, 1888. With its peristome enlarged and festooned, it is a very elegant species and easy to determine.

Occurrence.—Galapagos Islands, D. 2813 and D. 2815.

Cotypes.—Cat. Nos. 8487, 8488, U.S.N.M.

Genus HIPPOPORINA Neviani, 1895

HIPPOPORINA CLEIDOSTOMA Smitt, 1873

1873. *Lepralia cleidostoma* SMITT, Florida Bryozoa, Kongl. Svenska Vetenskaps Akademiems Handlingar, vol. 11, p. 62, pl. 11, figs. 217–219.

1928. *Hippoporina cleidostoma* CANU AND BASSLER, Fossil and Recent Bryozoa of the Gulf of Mexico Region, Proc. U. S. National Museum, art. 2710, p. 104, pl. 9, fig. 7, pl. 32, fig. 5.

Measurements.—

$$\text{Apertura}\begin{cases} ha=0.14 \text{ mm.} \\ la=0.10 \text{ mm.} \end{cases} \quad \text{Zooecium}\begin{cases} Lz=0.44 \text{ mm.} \\ lz=0.30 \text{ mm.} \end{cases}$$

Affinities.—Our specimens incrusted shell fragments, *Lithothamnion* and Cellepores. They generally conform well to the figures of Smitt, 1873. Some of our specimens have appeared doubtful, but

their state of preservation does not permit us to make a serious study.

All of the synonymies given for this species are false. The determinations made without illustration must be revised, and there is confusion between many species.

Biology.—Our specimens were in reproduction and fixation in April, 1888. In the Gulf of Mexico we have observed it in March and April, 1885. It is essentially a tropical species.

Geographic distribution.—Atlantic: Brazil, 27 fathoms; Gulf of Mexico; Habana, 201 fathoms; between Cuba and Yucatan, 24 fathoms; Florida, 30–133 fathoms; Fovey, 40 fathoms.

Geologic distribution.—Pleistocene of Panama.

Occurrence.—Galapagos Islands, D. 2813 and D. 2815.

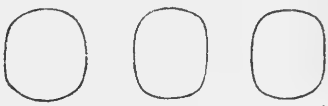
Cat. Nos. 8489, 8490, U.S.N.M.

Genus HIPPOMENELLA Canu and Bassler, 1917

HIPPOMENELLA PARVICAPITATA, new species

Plate 2, Figures 7–11

Description.—The zoarium incrusts the débris of shells and echinoids. The zooecia are distinct, separated by a deep furrow, somewhat elongated, elliptical or rectangular on the margins. The frontal is convex and formed by a pleurocyst surrounded by a triple row of areolar pores. The apertura, visible at the bottom of the peristome, is semielliptical. The peristomice bears two very small cardelles separating a very large anter from a very small concave poster. The ordinary zooecia bear a small triangular avicularium, adjacent to the peristome, transverse, the point oriented exteriorily. The marginal zooecia very much enlarged, bear two avicularia arranged symmetrically. The ovicell is *small*, very globular, marginated, and finely porous.



A B C

FIGURE 3.—HIPPOMENELLA PARVICAPITATA, NEW SPECIES. *A–C*, DIFFERENT FORMS OF OPERCULA, × 85

Measurements.—

$$\text{Apertura}\begin{cases} ha=0.14\text{–}0.16 \text{ mm.} \\ la=0.14\text{–}0.16 \text{ mm.}\end{cases} \qquad \text{Zooecium}\begin{cases} Lz=0.60\text{–}0.70 \text{ mm.} \\ lz=0.40\text{–}0.50 \text{ mm.}\end{cases}$$

Variations.—The zooecia are arranged in linear series branching dichotomously rather regularly, so that their size increases without ceasing from the center to the circumference. Our measurements relate to the cells placed at a distance from the border. The marginal cells are rectangular and considerably enlarged. The ancestrula is very small, of the ordinary form but deprived of avicularia.

The granulated pleurocyst placed on the median part is always very small, often even it disappears and the frontal appears as a true tremocyst. On the much calcified zooecia the peristome is thickened and festooned in the proximal portion.

The ovicell appears much smaller when it surmounts a wide zooecium. Its diameter measures 0.25–0.30 mm. This is one of the smallest dimensions observed in the genus. The operculum is very thin, semiellipitical, a little elongated without any visible insertion for the opercular muscles.

Our specimens were living and we have been able to photograph an embryo in its ovicell.

Affinities.—In the genus *Hippomenella* there are two rather distinct groups. In the first the peristome is mucronated and the ovicell is richly decorated; in the second there is no mucron and the ovicell is finely punctate (at least on the young cells). *Hippomenella parvicapitata* belongs to the second group, still little rich in species. It is very well characterized by its small dimensions. The ovicells of the other species measure at least 0.35 mm. in diameter.

Biology.—The species was in reproduction and fixation on April 7, 1888. All of our specimens were ovicelled. It incrusts especially the débris of shells; a single colony incrusted a fragment of echinoid.

The physiologic function of the small avicularia is not apparent. They do not appear even of any great utility for the greater part of the cells have only one.

Occurrence.—Galapagos Islands, D. 2813.

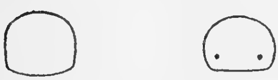
Cotypes.—Cat. No. 8491, U.S.N.M.

Genus MICROPORELLA Hincks, 1877

MICROPORELLA GIBBOSULA, new species

Plate 3, Figures 1, 2

Description.—The zoarium incrusts shells. The zooecia are distinct, separated by a deep furrow, somewhat elongated, irregularly hexagonal. The frontal is arched, ornamented by small tremopores and fine granules. The ascopore is small, median, sometimes oblique. The avicularium is small, triangular, with pivot, arranged transversely in the portion where the cell is widest and below the ascopore; the beak is oriented toward the exterior; the mandible is long, setiform, or, more rarely, lanceolated. The apertura is small, semielliptical; the peristome is little salient and bears five spines. The ovicell is globular salient, arranged on the distal zooecium, ornamented by pores identical with those of the frontal.



A B

FIGURE 4.—OPERCULA OF MICROPORELLA, × 85. A, M. TRACTABILIS, NEW SPECIES. B, M. GIBBOSULA, NEW SPECIES

Measurements.—

Apertura $\begin{cases} ha=0.08 \text{ mm.} \\ la=0.09 \text{ mm.} \end{cases}$ Zooecium $\begin{cases} Lz=0.50\text{–}55 \text{ mm.} \\ lz=0.45 \text{ mm.} \end{cases}$

Variations.—The micrometric variations are extraordinary; on certain specimens the marginal cells are twice as long as the cells close to the ancestrula. In order to get the average measurement, we have considered a rather large specimen in which all the zooecia were almost of the same dimension. The greatest length observed is 0.65 mm; the greatest width is 0.70 mm. on the transverse cells.

The avicularium is not rigorously transverse; it is a little oblique with the point directed toward the top. In reality it is almost always oriented parallel to the line of junction of two adjacent cells. It is placed to the right or to the left of the cell but always in a fixed portion of the colony.

Affinities.—In its operculum with two proximal attachments and in its lanceolated mandible this species resembles *Microporella coronata* Audouin, 1826, figured by Waters, 1909. It differs in the arched, hexagonal zoœcia, in the presence of a single avicularium placed below the ascopore and not of two avicularia placed at the level of the ascopore. These are the only two species provided with this kind of operculum so easily recognized.

Biology.—This is the most common species in the Galapagos Islands. Its fecundity is very great, as is also the resistance of its larva. The avicularia are the organs of relation in the bryozoa. They are not absolutely necessary to the life of the cell or the colony, but they reveal their habits and their instincts. As the latter are infinitely varied, we can only with difficulty interpret the multiple functions of these minute organs. Here the avicularium is constant in its position, its direction, and its presence; it is therefore zooecial, for it is of service to the cell and is indispensable to it. But for what function? It is the more difficult to conceive that in the small locality another species lives ornamented with avicularia absolutely different. The mandible is open and even flattened on the frontal when the tentacles are invaginated.

The object of the zooecial avicularia appears to be especially to stir the surrounding water and to direct it in a fixed direction. Of little import is the nature of the avicularium employed for this function if the object is attained. Heredity has fixed for each species the form and the advantageous position.

Our specimens were in reproduction and fixation April 7, 1888.

Occurrence.—Galapagos Islands, D. 2813.

Cotypes.—Cat. No. 8492, U.S.N.M.

MICROPORELLA TRACTABILIS, new species

Plate 3, Figures 3–5

Description.—The zoarium incrusts shells and Cellepores. The zooecia are distinct, little elongated, hexagonal; the frontal is convex, ornamented with tremopores and with very fine granules. The aperture is semielliptical, the peristome is thin, salient with straight proximal border, ornamented with five or six large spines. The ascopore is large, subtriangular, closed by a perforated lamella, surrounded by a salient, often oblique peristome always adjacent to the apertural peristome. On each side of the apertura there is a small triangular avicularium with pivot, the beak oriented toward the top; the mandible is setiform and always long enough to touch the avicularium of the adjacent superior zooecium. The ovicell is large, globular, ornamented by tremopores like the frontal.

Measurements.—

$$\text{Apertura}\begin{cases} ha=0.06\text{–}0.08 \text{ mm.} \\ la=0.10\text{–}0.12 \text{ mm.}\end{cases} \quad \text{Zooecium}\begin{cases} Lz=0.55\text{–}0.60 \text{ mm.} \\ lz=0.40\text{–}0.50 \text{ mm.}\end{cases}$$

Affinities.—The operculum is transverse and has a proximal border somewhat convex, when the proximal border of the peristome is rectilinear. The tremocyst has small pores. The ascopore is triangular, large, with a distal border somewhat concave; when it is oblique its form is that of a crescent.

This species has absolutely the structure of *Microporella californica* Busk, 1854. Compared with the recent specimens collected at Santa Monica, it differs from them in its avicularia placed higher above the level of the ascopore, less oblique, smaller, in its neater frontal verrucosities and in its larger zooecial dimensions (Lz=0.55–0.60 mm. and not 0.40–0.50 mm.).

Biology.—This is a very remarkable species because of its avicularia. The mandibles are very delicate and rather long setae. Their feeble hairlike dimensions compared with the great surface of the cells do not permit us to consider them as organs of oxygenation. Really they can scarcely agitate the surrounding water to an appreciable and sufficient manner, especially under a pressure of 40 to 60 meters. But the mandibles are always long enough to touch the pivot of the avicularia of the adjacent superior zooecia so that all the avicularia of the same colony are in tactile direct communication. Even on dried specimens this phenomenon is clearly apparent. The avicularia are here organs of tactile sensibility, justifying the specific name we have chosen. The simultaneity of the mandibular movements is the consequence of this ingenious arrangement. These avicularia are of little service to the zooecia which bear them, but they assure the biologic unity of the colony. They give us a good example of social discipline, each at the service of the other.

All the setiform mandibles of the incrusting cheilostome colonies appear to be rather organs of tactile sensibility than organs of oxygenation, but we can not always understand their immediate utility as well as in *Microporella tractabilis.*

One time more we must consider the avicularia as organs of relation. They are the eyes of animals that are without such organs. By their presence and their nature they constitute an important physiological perfection to be considered in the general classification.

Our specimens were living and ovicelled. They were in reproduction and fixation on April 7–9, 1888. We have not observed the ectocyst, probably because of the great desiccation of the specimens.

Occurrence.—Galapagos Islands, D. 2813 and D. 2815.

Cotypes.—Cat. No. 8493, U.S.N.M.

ENANTIOSULA, new genus

Greek: *Enantios:* inverse, referring to the appearance of the cells; *ula,* suffix indicating the absence of ovicell.

Escharellidae? Without ovicell. The zooecia are surrounded by a common row of parietal dietellae. The frontal is a tremocyst. The

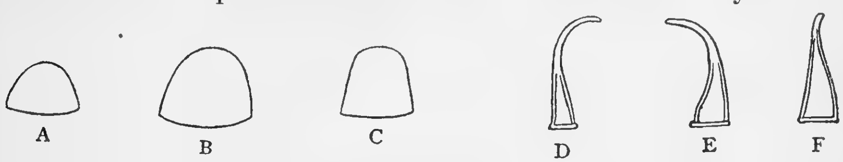


FIGURE 5.—ENANTIOSULA MANICA, NEW GENUS AND SPECIES. *A–C,* DIFFERENT FORMS OF OPERCULA, × 85. *D–F,* MANDIBLES OF AVICULARIUM, × 85

peristomice (apparent aperture) is semielliptic. The operculum has the form of a bell with concave proximal border. There are two oral avicularia with beak converging on the axis of the distal half of the aperture.

Genotype.—Enantiosula manica, new species. Recent (equatorial zone).

ENANTIOSULA MANICA, new species

Plate 3, Figures 6–11

Description.—The zoarium is free, formed of many lamellae superimposed and covering one over the other like the fingers of a glove. The zooecia are little distinct, separated by a shallow furrow, little elongated wide, ansiform. The frontal is somewhat convex, ornamented with tremopores on the young cells and with radial costules on the calcified ones. The apertura is semielliptical and transverse; the peristome is distal and little salient. On each side of the apertura there is an unguiculated avicularium adjacent to the peristome in which the beak reaches the distal half of the apertura.

Measurements.—

Apertura $\begin{cases} ha=0.12\text{–}0.14 \text{ mm.} \\ la=0.16 \text{ mm.} \end{cases}$ Zooecium $\begin{cases} Lz=0.60\text{–}0.80 \text{ mm.} \\ lz=0.40 \text{ mm.} \end{cases}$

Structure.—The zooecia are surrounded by large dietellae, but these are not special to each cell as in *Adeona.* They are common to the adjacent zooecia. The larger correspond to the avicularia which do not belong therefore in reality to the zooecium on which they appear placed but are truly interzooecial. The decoration on the young zooecia is very elegant. Here 8 to 12 tremopores are tubular and salient. The interstices fill up the progress of calcification and the frontal then has only radial costules and large lateral pores. Under this aspect they measure 0.60 by 0.40 mm. and the aperture 0.10 by 0.12 mm.

The colonies are large, of irregular form, vaguely ramified and with a curious aspect. The section shows the habitual arrangement of the superposed lamellae. The base is very broad. The summit of the branches, on the contrary, is very small, for the lamellae are here less numerous. The result of this singular arrangement is the orientation of the zooecia toward the base, an arrangement absolutely contrary to that observed on the other cheilostomes. As all the colonies were separated from their substratum without showing a trace of rupture we would judge that the latter was very fragile. They were undoubtedly attached beneath the marine algae.

This particular arrangement of superposed lamellae is frequent in the Ceriopores and the Heteropores in which the colonies are ascendant and more or less ramose. But their tubes are not oriented and we can very well conceive the normal arrangement of their tentacles. *Enantiosula manica* is, on the contrary, a cheilostome with oriented cells, and we can not see any other cause for their apparent inversion than the reversal of the colony itself.

The operculum is of great simplicity; its bell form is similar to that of *Codonella* and we have not seen any muscular attachment. The mandibles are more often unguïculate, rarely straight.

Biology.—The habits of this species are very curious. Each colony lives with its head at the base, attached to the more or less mobile substratum, as the irregularity of the forms observed proves. The food thus captured must also be rather special and very abundant in order to assure the growth of a relative large edifice and of the unusual cells.

Neither the beak of the avicularia nor the mandible are in immediate contact. The simultaneity of the movements of many cells at a time is certainly probable, since the avicularia are interzooecial and in contact with their mesenchymatous fibers which pass through the entire colony. The mandibles appear to close when the tentacles are withdrawn into the tentacular sheath.

The avicularia considered two by two are perpendicular. But on the very curved or small parts of the colony this geometric arrangement is changed. On the much calcified zooecia the avicularia have a very reduced shape, and the utility of their interposition there appears doubtful, or at least very slight use.

The intensity of the life is very great in the tropical zone. The least substratum is watched not only by the larvae of bryozoa, but also by the corals and by the spores of *Lithothamnion*. While the colony is living it is clean and never incrusted. We may suppose that the defensive rôle of the frontal and more particularly of the operculum is held by the avicularia when the cells are closed and by the tentacles when they are open.

Reproduction must occur as in *Cryptosula*, because here also there are no ovicells.

Occurrence.—Galapagos Islands, D. 2815.

Cotypes.—Cat. No. 8494, U.S.N.M.

Family PETRALIIDAE Levinsen, 1909

PACHYCLEITHONIA, new genus

Greek: *Pachys*, thick; *cleithon*=closure; referring to the thickness of the operculum.

The cells are gigantic in size. The frontal is a tremocyst not superposed on an olocyst. The aperture is arranged in the peristomie bearing two large condyles and two small symmetrical cups.

Genotype.—*Pachycleithonia nigra*, new species. Recent (Pacific).

We have classed this genus in the Petraliidae provisionally by simple analogy. The large size and the form of the cells are those of *Coleopora*. The peristomie presents the proximal undulations of certain *Petraliella*.

PACHYCLEITHONIA NIGRA, new species

Plate 4, Figures 9–13

Description.—The zoarium incrusts shells. The zooecia are unusually large, distinct, separated by a deep furrow, very elongated, elliptical; the frontal is a simple tremocyst with small pores; the ectocyst is thick and *black*. The peristomie is tubular, somewhat deep, perpendicular to the zooecial plane; it bears on the interior two large oblique condyles and two small lateral cups. The peristome is thin, smooth, complete; the peristomice is semicircular distally and bears in its proximal portion a rounded mucron and two sublateral denticles. The apertura is limited by the anter, the condyles, the cups, and the mucron.

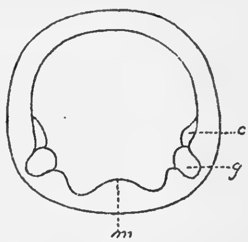


FIGURE 6.—PACHYCLEITHONIA NIGRA, NEW GENUS AND SPECIES. SKETCH OF THE ORIFICE OF A PERISTOME, × 85; *c*, OBLIQUE CONDYLES; *g*, CUP; *m*, PROXIMAL MUCRON

Measurements.—

Zooecium $\begin{cases} Lz=1.25\text{–}1.50 \text{ mm.} \\ lz=0.80\text{–}1.00 \text{ mm.} \end{cases}$ Peristomice $\begin{cases} hp=0.30 \text{ mm.} \\ lp=0.25 \text{ mm.} \end{cases}$

Structure.—The text figure represents the peristome and its orifice or peristomice drawn with the camera lucida. In the distal portion a large anter almost semicircular is noted. The proximal portion bears a broad, convex (or almost straight) mucron, limited on the sides by two concavities and laterally two orbicular indentations. Two large condyles, directed into the peristomie, separate the anter from the poster. The form of the operculum does not correspond at all to that of the peristomice.

In the interior of the peristomie, two small lateral, shallow cups (*g*) are lodged in the lateral indentations. They are not covered by the operculum. They are hidden by the ectocyst and they appear frequently as two lucidas on the visible closure. When they are not visible, the ectocyst is confused with the operculum and the closure showing exteriorly has a different form, but deceiving from that of the operculum.

In the interior of the cells there is no olocyst. The visible orifice which is the base of the peristomie, does not have the form of the operculum. The two large condyles are visible in perspective. The proximal border is rectilinear and continues to the zooecial walls in order to limit two small canalicules (*c*) placed exactly under the small cups of the peristomie.

The operculum is black, very thick, and we have been unable to see any muscular attachments. Its very special form has no analogy with any other known operculum. It closes the true aperture. In order that the latter correspond to it, it is necessary that it be placed in the peristomie itself and limited posteriorily by the condyles, the cups, and the exteriorily visible mucron. This very special arrangement is, however, compatible only with a rigid operculum. In the other known cheilostomes the apertura is placed at the bottom of the peristomie. The mucron, visible exteriorily, is, then, not a true mucron, for it does not have the protective function. It is a calcareous piece, rather variable in form, extending into the peristomie up to the apertura. The tremocyst, seen by transparency, is also very special and of an unusual aspect. Between the small tremopores there are small clear spaces vaguely polygonal, not limited, which can correspond only to the little calcified portions invisible in the ordinary light.

The ectocyst alone is a very deep brown almost black, but the calcareous walls of the zooecia are white without any trace of color.

This remarkable species is not rare. However, we have not observed ovicells. Specimens preserved in alcohol will be very desirable for anatomical study, for these alone can give us the information necessary to work out the biology.

Occurrence.—Galapagos Islands, D. 2813.

Holotype.—Cat. No. 8495, U.S.N.M.

Family SMITTINIDAE Levinsen, 1909

Genus SMITTINA Norman, 1903

SMITTINA RETICULATA J. MacGillivray, 1842

1889. *Smittina reticulata* JELLY, A, Synonymic Catalogue of Marine Bryozoa, p. 25 (General bibliography).

1908. *Smittina reticulata* ROBERTSON, The incrusting Cheilostomatous Bryozoa, of North America, University of California Publications, vol. 4, p. 306, pl. 23, figs. 75, 76.

1925. *Smittina reticulata* CANU and BASSLER, Les Bryozoaires du Maroc et de Mauritanie, Mémoires de la Société des Sciences naturelles du Maroc, vol. 10, p. 39 (supplementary bibliography).

We have found only a single dead specimen incrusting a Cellepore. This species is rare in the equatorial zone.

Occurrence.—Galapagos Islands, D. 2815.

Cat. No. 8496, U.S.N.M.

SMITTINA TRISPINOSA Johnston 1838, variety

Plate 4, Figures 1–5

1923. *Smittina trispinosa* CANU and BASSLER, North American Later Tertiary and Quaternary Bryozoa, Bulletin 125, U. S. National Museum, p. 143, pl. 22, figs. 7–14. (Bibliography, geologic distribution.)

Structure.—The colonies are large, multilamellar, ramose, dendroid, irregular; the base is orbicular, little expanded, fixed on agglomerated pebbles of the ocean bottom. This is the first time this species has been noted in this exuberant zoarial form.

At the extremity of the branches the zooecia are poorly oriented, separated by a salient thread with a granular frontal and rather large areolar pores. The peristomice is orbicular, with a concave proximal border. At the bottom of a very short peristomie there is a small, flat lyrule and two small, strong cardelles. The frontal bears two small elliptical avicularia arranged on each side of the aperture or irregularly below it with the beak oriented toward the proximal portion of the cell.

On the branches the zooecia are more decorated.. Frequently a large avicularium is developed at the side and even above the aperture; its mandible is solid, falciform, never spathulate; the beak is oriented toward the proximal portion of the cells. On the other

zooecia the avicularia are irregularly disseminated; they are often elliptical and oriented toward the inferior portion of the cells, but frequently there are triangular avicularia with pointed beak oriented toward the superior portion.

The triangular avicularia are observed ordinarily on the typical form. The large avicularium is characteristic of the variety *nitida* Hincks, 1881. The aperture and the zooecial form are also those of the same variety. This mixture of characters causes us to doubt the reality of the numerous varieties cited for this proteiform species.

The cells are oriented in all directions; this is the celleporine structure of Smitt. The species consequently exhibits the development of a colony like a true Cellepore. However, the internal structure is not that of a Cellepore, for the lamellae are very regularly superposed, the zooecia of one above the other. It should be observed that the irregular orientation of the cells is observed on the colonies of the same form.

Biology.—The aspect of the large colonies is identical with that of the Cellepores. We have shown (Maroc, p. 54) that the special and irregular development is a special adaptation to a mobile substratum. In *Smittina trispinosa* var. the same phenomena are apparent. The more or less agglomerated sands and pebbles on which the colonies are fixed constitute a substratum without solidity and rigidity, analagous to the floating algae. In order to develop, the animal must constantly rectify its equilibrium which is compromised unceasingly by causes impossible to foresee or to observe. The disconcerting irregularity of the colony is, therefore, quite justified. What are the means employed to assure the equilibrium? The principal ones are the irregularity of budding and the nonorientation of the cells. *Smittina trispinosa* has this property of modifying at will the orientation of the cells, a characteristic very rare in the noncelleporidan Cheilostomes. It is not simply by caprice that a normal zooecium engenders an inverse one for it certainly complies with a zoarial necessity.

The zooecia provided with large avicularia are the ordinary zooecia having the same form, the same irregularity and the same frontal. They are generally a little larger than their neighbors. A third at least of their surface is occupied by the avicularium. The aperture is no longer subterminal but is considerably removed from the distal end. The polypide in order to lodge in the narrow space available must necessarily be dwarfed or twisted abnormally. Anatomic studies by decalcification would be very desirable and would perhaps determine the physiologic action of the large avicularium. The latter is arranged obliquely in such a fashion that it passes above the aperture in opening or closing. It is difficult to evaluate the force and efficacy of the movements of the avicularium but as they are ex-

ecuted in different ways on each cell, we must suppose that they are zooecial and not zoarial; they are useful only to the zooecia which bear them. We found only a single living specimen with ectocyst and ovicell at station D. 2815. The species was in reproduction April 9, 1888.

Occurrence.—Galapagos Islands, D. 2813 and D. 2815.

Plesiotypes.—Cat. Nos. 8498, 8499, U.S.N.M.

Genus CODONELLA, new genus

Greek, *codon*=bell, referring to the form of the operculum

Smittinidae in which the ovicell is hyperstomial, closed by the operculum, porous and marginated. The frontal is a tremocyst. A median avicularium is placed before the aperture. The peristome is salient and complete. The aperture is suborbicular with a very concave poster; the peristomice bears two false cardelles, limiting laterally a broad rounded sinus. There are oral glands and 15 to 17 tentacles.

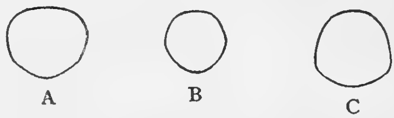


FIGURE 7.—CODONELLA GRANULATA, NEW GENUS AND SPECIES. THREE FORMS OF OPERCULA, × 85

Genotype.—*Codonella* (*Lepralia*) *galeata*, Busk, 1852.

The species appearing to belong to this genus are:

Codonella (*Lepralia*) *galeata* Busk, 1852	Antarctic.
Codonella (*Lepralia*) *obtusata* Ortman, 1890	Japan.
Codonella (*Lepralia*) *acuta* Ortman, 1890	Japan.
Codonella (*Schizoporella*) *pellucida* Ortman, 1890	Japan.
Codonella (*Porella*) *cribriformis* O'Donoghue, 1923	Vancouver.
Codonella (*Lepralia*) *pachnoides* MacGillivray, 1886	Australia.
Codonella (*Lepralia*) *montferrandi* Audouin, 1826	Red Sea.
Codonella, species	Hawaii.

Exteriorly, in the form of the visible aperture (or peristomice) this genus resembles *Schizomavella* very much. In the fossils it would be almost impossible to note the difference, for only the preparation of the operculum permits the recognition of the true form of the aperture.

The difference from *Porella* is slight and consists only in the form of the operculum and the peristomice.

CODONELLA GRANULATA, new species

Plate 4, Figures 6–8

Description.—The zoarium incrusts shells, nullipores, and bryozoa. The zooecia are distinct, separated by a deep furrow, elongated, elliptical; the frontal is quite convex and formed of a very granular

tremocyst. The median avicularium is triangular, acuminate, the beak below, adjacent to the peristome. The apertura is large orbicular with a simply concave proximal border; the peristome is salient, indented in front by a broad, round rimule. The ovicell is large, globular, salient, buried in the distal zooecium, perforated by small pores, and margined by a large salient collar.

Measurements.—

Apertura $\begin{cases} ha = 0.14 \text{ mm.} \\ la = 0.14 \text{ mm.} \end{cases}$ Zooecia $\begin{cases} La = 0.55\text{–}0.60 \text{ mm.} \\ la = 0.30\text{–}0.40 \text{ mm.} \end{cases}$

Structure.—This species is very deceiving. Without the preparation of the operculum and the interior we would have classed it in *Schizomavella.* It is only the peristomice which has the schizoporellidan form; the form of the apertura is different.

Certain colonies have a curious form of successive palm-shaped branches, as in *Berenicea.* There are four uniporous septules. As in other genera of Smittinidae, the operculum is very thin and without any ornament.

Affinities.—The closest species is *Lepralia pachnoides* MacGillivray, 1886, of Australia, but the present form differs in its suborbicular (not subelliptic) aperture and in the presence of numerous frontal granulations.

Biology.—Our specimens were in reproduction on April 7, 1888.

Occurrence.—Galapagos Islands, D. 2813 and D. 2815.

Cotypes.—Cat. Nos. 8500, 8501, U.S.N.M.

Family RETEPORIDAE Smitt, 1867

DIPLONOTOS, new genus

Greek; *diplos,* double; *notos* back; referring to the double dorsal of the zoarium.

Reteporidae in which the two faces of the reticulated colony are covered by vibices. The zooecia are arranged on the edges of the branches in the fenestrae.

Genotype.—Diplonotos costulatum, new species. Recent (equatorial Pacific).

The reticulated colony and the presence of the vibices have caused us to class this genus in the Reteporidae. In reality we are ignorant of the ovicell, the operculum, the aperture, and the frontal structure.

DIPLONOTOS COSTULATUM, new species

Plate 5, Figures 1–4

Description.—The zoarium is free, reticulated, composed of principal branches bearing pinnules; the latter often join the neighboring branches forming a kind of fenestrae; the branches are sub-

cylindric, slightly compressed. The two faces of the colony are covered by salient vibices outlining polygonal spaces in each of which there is an elliptical avicularium and sporadically, radial sculpture. The zooecia are arranged on the edge of the branch in the fenestrae and in a single row; they are little distinct, separated by a salient thread, little elongated, wide; the frontal bears salient longitudinal nervures. The apertura is oblique, located at the bottom of a parietal peristomie and hidden by a salient, more or less sinuous mucron. Two small lateral avicularia are placed at the extremities of the transverse axis of each zooecium.

Biology.—We have found only small dead and incomplete fragments of this strange species and therefore are unable to make a serious study. The function of the vibices in the Reteporidae being unknown, we are not able to explain their presence on the two faces of the colony. One must admire the really prodigious work accomplished by the two simple rows of cells of each branch, their length being only 0.70 mm. Their architectural ability must be accompanied by an enormous voracity, for which reason there is a large number of avicularia. The function of the latter must be to chase the plancton into the fenestrae, where it is easily snapped up by the tentacles.

Occurrence.—Galapagos Islands, D. 2813 and 3408.

Holotype.—Cat. Nos. 8502, 8503, U.S.N.M.

DIPLONOTOS STRIATUM, new species

Plate 10, Figures 1–3

Description.—The zoarium is free, ramified, with cylindrical or somewhat compressed pinnules. The latter bear two rows of cells placed opposite each other and arranged laterally. The branches are very finely striated by delicate and incomplete sulci at the bottom of which are minute scattered vacuoles. Salient vibices occur in the wider portions, which give the branches a vague articulated aspect. Between two vibices there are at least three cells. The zoarial epitheca is very thick and formed of numerous cylindrical lamellae. The zooecia are indistinct, elongated, oriented laterally toward the adjacent pinnules. The aperture is broad, very little elongated, and bears a small proximally rounded sinus. No peristome. Ovicell unknown. Some of the lateral vacuoles are transformed into small avicularia.

Measurements.—

Apertura $\begin{cases} ha=0.22\text{–}0.24 \text{ mm.} \\ la=0.20\text{–}0.22 \text{ mm.} \end{cases}$ Zooecia $\begin{cases} Lz=1.00\text{–}1.60 \text{ mm.} \\ lz= \quad ? \end{cases}$

Diameter of the large branches, 2 mm.

Affinities.—This second species of *Diplonotos* differs from the genotype *D. costulatum*, new species, in the much larger zoarial dimensions, in the absence of an oral mucron, in the absence of nervules on the cells, in the much rarer and transversely arranged vibices, and in the presence of sulci and of vacuoles. The number of fragments collected does not permit a more detailed study of this strange species.

Occurrence.—Galapagos Islands, D. 3408.

Cotypes.—Cat. No. 8504, U.S.N.M.

Family CREPIDACANTHIDAE Levinsen, 1909

Genus CREPIDACANTHA Levinsen, 1909

Norman, 1907, has given the bibliography of the genotype *Flustra poissonii* Savigny-Audouin, 1828. In 1926 we rediscovered this species as a fossil at Panama, and we also gave its bibliography. In 1929 (Philippines) we specified the characters of the genus and we tried to clear up the known species and those confused with the genotype, describing three new species. We can now give the list of the known species and outline the geographic extension.

Recent species.—

Crepidacantha (*Flustra*) *poissonii* Audouin, 1826 ______ Atlantic, Pacific.
Crepidacantha (*Hippothoa*) *setigera* Smitt, 1873 ______ Gulf of Mexico.
Crepidacantha longiseta Canu and Bassler, 1928 ______ Gulf of Mexico.
Crepidacantha crinispina Levinsen, 1909 ______ Siam, Australia.
Crepidacantha setifera, new name (=*Lepralia poissonii* MacGillivray, 1882). Australia.
Crepidacantha solea, new name (=*Lepralia poissonii* Kirkpatrick, 1888). China Sea.
Crepidacantha zelanica, new name (=*Lepralia poissonii* Waters, 1889). New Zealand.
Crepidacantha papulifera Canu and Bassler, 1929 ______ Sulu Sea.
Crepidacantha altirostris Canu and Bassler, 1929 ______ Sulu Sea.
Crepidacantha grandis Canu and Bassler, 1929 ______ Pacific (Philippines).

Fossil species.—

Crepidacantha (*Lepralia*) *odontostoma* Reuss, 1874 ___ Miocene (Europe).
Crepidacantha (*Flustra*) *poissonii* Audouin, 1826 ______ Pleistocene (Panama).
Crepidacantha parvipora, new name (=*Lepralia poisonii* Hincks, 1885) ______ Miocene (New Zealand).

This is an equatorial genus. Only the genotype occurs as far north as Madeira, so that it passes but little from the warm zone. The bathymetric dispersion is quite variable even for the same species. However, the depths observed are never great. Below 120 meters representatives of the genus are very rare.

CREPDIDACANTHA POISSONII Savigny-Audouin, 1826

Plate 5, Figure 5

1928. *Crepidacantha poissonii* CANU and BASSLER, Bryozoaires des Iles Hawaii, Bull. de la Société des Sciences de Seine et Oise, fasc. 7, p. 37, pl. 8, fig. 7.

Measurements.—

Apertura $\begin{cases} ha=0.10 \text{ mm.} \\ la=0.08 \text{ mm.} \end{cases}$ Zooecia $\begin{cases} Lz=0.54\text{–}0.60 \text{ mm.} \\ lz=0.40 \text{ mm.} \end{cases}$

Structure.—This species is very vigorous in the Galapagos Islands, and its dimensions are somewhat larger than those of a specimen from the Hawaiian Islands, of which we give a photograph. The characters are quite the same as those of specimens from Madeira and Panama. The ovicell is decorated with a distal border and the two vibracula are placed below the aperture. The latter are not always arranged symmetrically (as in Panama), but they are somewhat more removed from each other as at Madeira.

The operculum has the ordinary form of the opercula of the species dredged at the Philippine Islands, with two lateral bands curved for muscular attachments.

Affinities.—Hincks, 1885, wrote that at Tahiti and New Zealand "two forms occur—in one the vibracula are situated below the orifice and are placed horizontally (=typica); in the other they are vertical and placed at the side of the orifice near the top of it and close to the margin (=new species)." He cites also a common fossil in New Zealand a variety of *Crepidacantha poissonii* with "orifice very small and the vibracula are placed in good way down the cell with a prominent central umbo between them." This is a distinct species which we have called *Crepidacantha parvipora.*

Waters, 1887, also cites from New Zealand *Lepralia poissonii*, of which he gives the operculum. This is not the same as our identification of the species because he has selected the second form with lateral vibracula, which Hincks mentions in 1885. We have called this species *C. zelanica*, although we can not give all the characters, for we know only the operculum and the place of the avicularia. It is perhaps *Crepidacantha setigera* MacGillivray, 1882 (not Smitt, 1873); but we have no illustration permitting as to make this synonymy. Moreover MacGillivray's species, differing notably from that of Smitt, has caused us to change his specific name and to call it *Crepidacantha setifera.* Hincks, 1885, in writing that the place of the vibracula was of no importance appears to have caused all the confusion.

Finally Waters, 1889, figures a variety of *Crepidacantha poissonii* from Australia with an ovicell "immersed"; that is to say, endo-

zooecial. This is perhaps only an appearance, and it is necessary to dissect this ovicell in order to be certain of its nature.

We do not believe that the mandibles of this species are really the bristles of vibracula. They do not have the organs of articulation which permit movement in every direction. To us they are setiform mandibles of true avicularia, for they can move only in a certain way, variable, however, in each species.

Biology.—Our specimens from the Galapagos Islands incrust dead shells and *Lithothamnion.* They were in reproduction on April 7 to 9, 1888, and in March, 1902. They appear to have lived on the bottoms dredged at that time. The species has not yet been rediscovered living in the Gulf of Mexico. It has lived there, however, because we have found it as a fossil in the Pleistocene of Panama. It was doubtless transported from Madeira by the equatorial current. Its presence in the Pacific is therefore ancient and dates to the time when the Isthmus of Panama had not yet formed. The large migratory fish have transported its larvae across the Pacific to the Hawaiian Islands and Tahiti, and even farther.

The length of the mandibles is equal to the distance between the two avicularia. The mandibles form a cross on the frontal. They appear to be tactile organs, but special to the zooecium which bears them.

Occurrence.—Galapagos Islands, D. 2813 and D. 2815; Hawaiian Islands, 325–483 meters and 5.3° C., D. 3813 (265–302 meters); Tahiti and New Zealand (Hincks); Madeira (30 fathoms). Red Sea and Gulf of Suez (Norman). Pleistocene of Panama (Canu and Bassler).

Plesiotypes.—Cat. Nos. 8505, 8506, U.S.N.M.

Family ADEONIDAE Jullien, 1903

Genus ADEONA Lamouroux, 1916

ADEONA TUBULIFERA, new species

Plate 5, Figures 6–9

Description.—The zoarium incrusts shells and nullipores. The zooecia are distinct, separated by a furrow, elongated, elliptic, swollen; the frontal is convex and ornamented with two rows of large areolar pores. The peristomie is *tubular*, very long, and very oblique on the young zooecia, shorter and little oblique on the much calcified zooecia; the peristome is thick and smooth; the peristomice is suborbicular, more often somewhat transverse. A thin triangular avicularium, the beak oriented superiorly, is placed on the peristomie. The

ascopore is large, lunate arranged on the frontal at the bottom of the peristomie. The gonoecia are very broad without peristomie and without avicularia. The ancestrula is a small ordinary zooecium.

Measurements.—

Zooecium $\begin{cases} Lz=0.60\text{–}0.70 \text{ mm.} \\ lz=0.44\text{–}0.48 \text{ mm.} \end{cases}$ Peristomice $\begin{cases} hp=0.10\text{–}0.12 \text{ mm.} \\ lp=0.10\text{–}0.12 \text{ mm.} \end{cases}$

Variations.—The zooecia with very long peristomie border only the zoarial margins; they are observed also on the very small colonies and around the ancestrula. They, therefore, characterize the young cells. On the others the reduction of the length must correspond to a great thickening of the frontal. The width of the zooecia is variable and may measure 0.60 mm. All of our specimens were dead, and we have observed only two gonoecia.

Occurrence.—Galapagos Islands, D. 2813 and D. 2815.

Cotypes.—Cat. No. 8507, U.S.N.M.

Family PHYLACTELLIDAE Canu and Bassler, 1917

Genus LAGENIPORA Hincks, 1877

LAGENIPORA VERRUCOSA, new species

Plate 6, Figure 1

Description.—The zoarium incrusts dead Cellepores. The zooecia are distinct, separated by a deep furrow, and have the form of a swollen bottle; the frontal is very convex, verrucose, formed by a tremocyst with small pores superposed upon an olocyst. The peristomie is oblique, short, smooth at the extremity, partially covered by the tremocyst; the peristome is thick, smooth, orbicular. The aperture hidden at the bottom of the peristomie is elongate, elliptic. The ovicell is small, opening into the peristomie above the aperture, finely perforated, marginated by a salient thread. The ancestrula is a small ordinary zooecium.

Measurements.—

Zooecium $\begin{cases} Lz=0.75\text{–}0.80 \text{ mm.} \\ lz=0.50 \text{ mm.} \end{cases}$ Apertura $\begin{cases} ha=0.16 \text{ mm.} \\ la=0.14 \text{ mm.} \end{cases}$

Structure.—It is easy to follow on our photograph the development of the ovicell. It develops at the same time as the peristomie elongates and the peristome grows definitely above it. It is of endocystal nature and inserted between the olocyst and the tremocyst; the frontal is therefore olocystal and the bordering thread the vestige of the tremocyst arrested in its development. This mode of formation and structure appear to be general in the genus. The ancestrula shows no particular character and is surrounded by five zooecia. Its

peristome presents traces of spines. Our specimens were living and ovicelled April 9, 1888.

Occurrence.—Galapagos Islands, D. 2815.

Holotype.—Cat. No. 8508, U.S.N.M.

LAGENIPORA MARGINATA, new species

Plate 6, Figures 2–3

Description.—The zoarium incrusts shells and often dead *Cupularia umbellata;* it is formed of large linear branches, generally triserial, sometimes spreading out palm shaped. The zooecia are distinct, *margined* by a salient thread, much elongated; the frontal is a tremocyst with very small pores separated by very fine granules, superposed on the olocyst; it is convex and supports laterally two small orbicular avicularia. The peristomie is short, very oblique, costulated; the peristome is orbicular and irregularly denticulated. On the long peristomies the peristome is widened and adorned with denticles and very irregular spicules. The ovicell is very small, always fixed at the base of the peristomie, and ornamented with a small, finely perforated area. The ancestrula is a small ordinary zooecium.

Measurements.—

$$\text{Zooecium}\begin{cases} Lz = 0.60\text{–}0.7 \text{ mm.} \\ lz = 0.30 \text{ mm.} \end{cases} \qquad \text{Apertura}\begin{cases} ha = 0.12 \text{ mm.} \\ la = 0.10 \text{ mm.} \end{cases}$$

Variations.—Uni or biserial branches are not rare. The colony is most often fixed on very small objects. The movements of the latter do not bother it. It develops on occasions on both sides of the substratum, and we have seen it even on the edge of the small shell fragments.

The peristomie is generally short; it is much elongated according to rule in the sheltered or narrowed parts of the substratum. The peristome then enlarges considerably and presents the most fantastic cut edges.

Affinities.—This species differs from *Lagenipora spinulosa* Hincks in its much greater dimensions, in its more numerous pores, its shorter periostomie, and the presence of small frontal avicularia.

Biology.—Most of our specimens were living, and many of them were ovicelled April 7, 1888.

The habits of *Lagenipora* resemble very much those of *Proboscina* which in the Cyclostomata have the same zoarial arrangement.

Occurrence.—Galapagos Islands, D. 2813.

Cotypes.—Cat. No. 8510, U.S.N.M.

Family CELLEPORIDAE Busk, 1852

Genus HOLOPORELLA Waters, 1909

HOLOPORELLA QUADRISPINOSA, new species

Plate 6, Figures 4–6

Description.—The zoarium incrusts bivalves, gastropods, cellepores, and algae. The zooecia, oriented or marginal, are distinct, separated by a deep furrow, elongated, elliptical; the frontal is convex, granulated, sometimes decorated with areolar pores and with small elongated avicularium with pivot. The peristome is salient, thin, decorated with four spines; the apertura is semielliptic and placed at the bottom of the peristomie. In front of the aperture

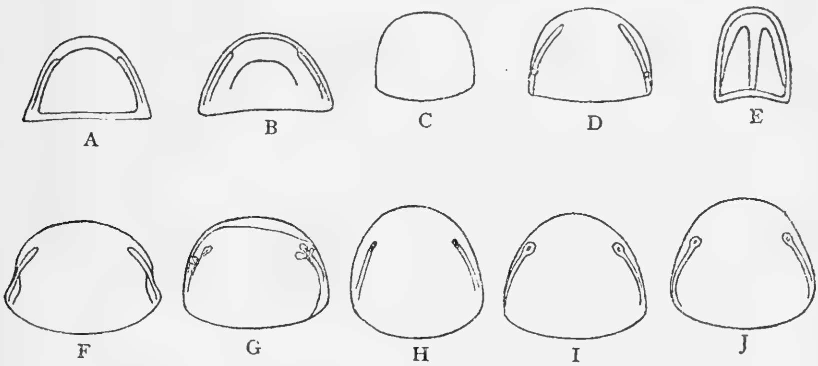


FIGURE 8.—GENUS HOLOPORELLA WATERS, 1909. *A*, *B*, OPERCULA, × 85 OF H. TRIDENTICULATA BUSK, 1881, THE FIRST WITH THE PROXIMAL BORDER AND THE SECOND BEARING TRACES OF THE TENTACULAR SHEATH. *C–E*, H. QUADRISPINOSA, NEW SPECIES. *C*, *D*, TWO OPERCULA, × 85, AND *E*, MANDIBLE OF AN INTERZOOECIAL AVICULARIUM, × 85 WITH THICK BORDER AND A COLUMNELLA. THE INTERIOR DECORATIONS MARK THE LIMITS OF THE MUSCULAR FIBERS. *F*, *G*, H. HEXAGONALIS, NEW SPECIES. OPERCULA, × 85. *H–J*, H. POROSA, NEW SPECIES. DIFFERENT FORMS OF OPERCULA, × 85

there is a small triangular avicularium, the beak at the top; it limits at its base a pseudorimule formed in the peristomice. The cumulate zooecia are irregular, granulated, ornamented sporadically by rare areolar pores or by small, elliptical avicularia. The peristome is nonsalient and bears two spines. The interzooecial avicularia are narrow, little elongated, with pivot. The ovicell is globose, widely opened above the operculum, much granulated as the frontal.

Measurements.—

Apertura $\begin{cases} ha=0.15 \text{ mm.} \\ ha=0.18 \text{ mm.} \end{cases}$ Oriented zooecia $\begin{cases} Lz=0.50\text{–}0.60 \text{ mm.} \\ Lz=0.35\text{–}0.40 \text{ mm.} \end{cases}$

Structure.—At first sight this species resembles *Schizostoma* because of its pseudorimule cut in the peristomice. Close observation shows that this is in reality formed by the projection of the small

oral avicularium and a projection of the peristome and that its plane is oblique to the plane of the apertura.

The colonies are very often adorned with marginal oriented cells They are never visible on floating specimens.

The operculum is in the form of a bell with the two lateral bands near the border.

Affinities.—All of the affinities of this species are with *Cellepora bispinosa* Busk, 1852, from Australia; the same frontal, ovicell, oriented cells, and the same pseudorimule in front of the apertura. Busk, 1852, figures two spines on the marginal zooecia; MacGillivray did not figure them, but indicates two large articulated spines on the cumulate zooecia.

If the operculum figured by us had been identical with that of MacGillivray, we would not have created a new species; the position of four spines on the oriented zooecia and the two on the cumulate zooecia indicated only varietal characters. MacGillivray's figure is so abnormal in the genus that it is perhaps erroneous.

Biology.—The ectocyst is white. Some rare living specimens were ovicelled April 7 to 9, 1888.

The specimens incrusting shells appear to have lived on the bottom where dredged, but a certain number of other specimens are attached to filaments of algae; they are cylindrical or similar to our Figure 4. Colonies developed on both sides of a fragment of shell or surrounding entirely a piece of coral are also subfloating. By floating specimens we do not intend to imply that they float freely as *Cupularia* or *Conescharellina*; we mean only that they are developed on or attached to floating bodies and that they have no bathymetric significance. There were often mollusks attached to the tufts of marine algae, and it is these which these organisms like the Cellepores entirely surrounded.

Holoporella quadrispinosa is therefore a species both fixed and floating.

Occurrence.—Galapagos Islands, D. 2813 and D. 2815.

Cotypes.—Cat. Nos. 8511, 8512, U.S.N.M.

HOLOPORELLA HEXAGONALIS, new species

Plate 7, Figure 1

Description.—The zoarium incrusts débris of shells. The zooecia are distinct, separated by a furrow, rather regularly hexagonal, non-oriented; the frontal is convex and covered with scattered pores. The apertura is semielliptic or suborbicular, median; it is surrounded by four salient avicularian tuberosities.

Measurements.—Apertura, $la=0.20$ mm. Zooecium, $lz=0.50$–0.65 mm.

Affinities.—The tuberosities are directed obliquely on the apertura; they modify the exterior aspect.

The operculum is transverse in the form of a bell, somewhat sinuate laterally. The muscular attachments are very narrow and close to the border. In its frontal tuberosities this species is close to *Lepralia turrita* Smitt, 1873, but differs in its rather regularly hexagonal cells and its porous frontal.

Only the figured specimen was found; it was living but not ovicelled.

Occurrence.—Galapagos Islands, D. 2813.

Holotype.—Cat. No. 8513 U.S.N.M.

HOLOPORELLA POROSA, new species

Plate 6, Figures 7, 8

Description.—The zoarium is globular, hemispheric, fixed to nullipores. The zooecia are distinct, separated by a furrow, orbicular or polygonal; the frontal is convex and covered with large scattered pores. The apertura is median, semielliptic, somewhat elongated with proximal, concave border. The ovicell is very large and convex, with a median area covered by pores smaller than those of the frontal; it is never closed by the operculum.

Measurements.—

$$\text{Apertura}\begin{cases} ha=0.22 \text{ mm.} \\ la=0.18\text{–}0.20 \text{ mm.}\end{cases}$$

Affinities.—This species differs from *Holoporella hexagonalis* in the absence of tuberosities around the apertura and in the special nature of the muscular attachments of the operculum.

The operculum is light colored and rigid. It has the form of a bell with a very concave proximal border. The muscular attachments are much thickened and each terminates in a point.

Biology.—The single specimen dredged was living and ovicelled April 9, 1888.

Occurrence.—Galapagos Islands, D. 2815.

Holotype.—Cat. No. 8514, U.S.N.M.

HOLOPORELLA TRIDENTICULATA Busk, 1881

Plate 7, Figures 2, 3

1881. *Cellepora tridenticulata* BUSK, Note on the chitinous organs in the Cheilostomata, Journal Linnean Society, vol. 15, p. 347, pl. 26, fig. 9.

1884. *Cellepora tridenticulata* BUSK, Challenger, p. 188, pl. 29, fig. 3; pl. 35, fig. 17 (operculum).

1885. *Cellepora tridenticulata* WATERS, Aldinga, Quarterly Journal Geological Society, vol. 41, p. 306.

1886. *Cellepora tridenticulata* MACGILLIVRAY, Prodromus Zoology Victoria decade 13, p. 110, pl. 128, fig. 3.

1887. *Cellepora tridenticulata* WATERS, On Tertiary Bryozoa from New Zealand, Quarterly Journal Geological Society, vol. 43, p. 68.

1890. *Cellepora tridenticulata* KIRKPATRICK, Hydroida and Polyzoa, Torres Straits, Scientific Proceedings, Royal Dublin Society, vol. 6, p. 612.

1895. *Cellepora tridenticulata* MACGILLVRAY, A monograph of Tertiary Polyzoa of Victoria, Transactions of the Royal Society of Victoria, p. 107, pl. 14, figs. 4–6.

Measurements.—

Apertura $\begin{cases} ha = 0.14\text{–}0.16 \text{ mm.} \\ la = 0.16\text{–}0.20 \text{ mm.} \end{cases}$ Diameter of tubes, 0.30 mm.

Variations.—The species of the *tridenticulata* group are quite variable and easy to confuse among themselves. The published figures of *Holoporella tridenticulata* are incomplete, and it is rather difficult to get an exact idea of the species. Fortunately, the published determinations having been made by actual comparison of specimens, the bibliography is exact.

The apertural width is 0.16–0.20 mm. measured on the same large zoarium. It is about 0.16 mm. on fossil specimens from the Balcombian of Muddy Creek, Australia, and on the recent examples of Busk, 1884, while the one from Australia (Waters, 1885) shows 0.20 mm. The aperture is always transverse.

The lyrule and the two cardelles are very resistant, rather large, sometimes bifurcated. They disappear only by mutilation after death. Even on the fossils they persist sufficiently to permit determination. Our specimens did not have oral spines. There are two on Busk's figure, 1884, and two to four on those of MacGillivray, 1886; they are often lacking on the fossils from Australia.

The surface of the cell is smooth. It is granular as figured by Busk, 1884, and MacGillivray, 1886, but on the fossils from Australia it is smooth or granular. The areolar pores are large, rare, and very irregularly distributed. They are more numerous and more regular on the fossils from Australia. There are none on the recent specimens figured by Busk and by MacGillivray. There is not a single interzooecial avicularium. Waters, 1885, said that they were very rare. Busk, 1884, found and figured the mandible on a recent specimen from Australia. On our fossils from Australia they were very numerous and never elliptical. Although variable, they are generally long, narrow, a little constricted in the middle of their length.

Sporadically, between the zooecia, long cylindric tubes spring forth on which there is neither operculum nor denticles. This is the first time that they have been figured. Busk, 1884, noted them thus: "Another curious feature is the frequent occurrence on the surface of the zoarium of long tubular processes or tunnels, looking like enormously elongated zooecia. The nature of these appendages appears very obscure." MacGillivray (1886 and 1895) did not rediscover them on his specimens recent or fossil. They are observed only on

the large colonies. The colonies are massive, mammillated, more or less expanded, thickened, the largest measuring 3 centimeters in diameter. On the inferior face, they appear to be formed of superposed lamellae; the section does not confirm this appearance; these pseudolamellae are only foliaceous expansions emitted by the colony probably for the purpose of general consolidation. The same phenomenon is noted by MacGillivray, 1895, in the variety *nummularia*, but the concentric ridges cited by the author do not indicate at all in section true superposed lamellae.

Busk, 1884, indicated a free, lamellar zoarium. MacGillivray, 1886, observed only small incrusting colonies. Fossil specimens from Australia have small incrusting colonies. The variety *numullaria* is formed of free specimens, more or less globular, but of small dimensions. Waters, 1885, indicates colonies of 25 millimeters among the fossils of *Aldinga*. These variations are habitual in the Cellepores, for the hazards of their precarious life causes them to die at all ages.

The operculum has very thick margins; the lateral bands are discerned with difficulty. We are not certain of our restoration. Busk, 1881, appears to have encountered the small difficulties, for his operculum is incomplete. New preparations are very desirable.

Biology.—The colonies have a brown ectocyst. The ovicell has never been discovered but it has been observed on another species of the same group. The sporadic salient tubes also have an unknown zoarial function. When this species is better known it will certainly reveal to us a curious biologic history.

From inspection of the colonies it is a species both fixed and floating. The floating specimens hang directly to algae or to nullipores, themselves attached to floating algae. A substratum so inconstant and mobile can support only free colonies irregularly developed. The lamellar expansions of the inferior face are simply a sort of clamp destined to better fix the colony to its substratum. Only the specimens collected with their substratum have a bathymetric value.

The small denticles of the apertural poster (lyrule and cardelles) are identical with those of *Smittina*, *Porella*, *Mucronella*, and *Petralia.* Their function must be identical, namely, to limit the movement of the operculum and to block it when it is closed. This is an equatorial species.

Occurrence.—Galapagos Islands, D. 2815.

Geographic distribution.—Pacific: Cape York (8 fathoms), Port Phillip Head and Warnamboul in Australia (Busk, MacGillivray); Torres Strait, 15–20 fathoms (Kirkpatrick).

Geologic distribution.—Miocene of Australia and New Zealand (Waters, MacGillivray).

Plesiotypes.—Cat. No. 8515, U.S.N.M.

Genus OSTHIMOSIA Jullien, 1888

OSTHIMOSIA ANATINA, new species

Plate 7, Figures 4–8

Description.—The zoarium is free, ramose, with branches rather regularly cylindrical or compressed. The zooecia are irregularly erect and oriented. The frontal is smooth or very slightly granulose, surrounded by areolar pores. The aperture is terminal, suborbicular, very little elongated; the rimule is wide, rounded, shallow, and is partially hidden by a large very salient avicularian umbo with semicircular mandible. The ovicell is large, globular, perforated by large pores arranged in quincunx, not closed by the operculum. The interzooecial avicularia are large, long, salient, oval, without pivot, with two condyles for the rotation of the mandible; the orifice is formed by a narrow, elongated, oval proximal opesium and a very much enlarged distal calcified area; the mandible is large with duck-bill form. The umbo of the deep zooecia projects between the superficial zooecia in the form of small cylindrical, avicularian tubes.

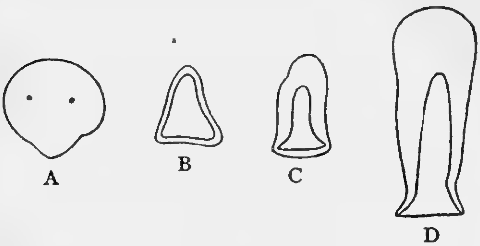


FIGURE 9.—OSTHIMOSIA ANATINA, NEW SPECIES. *A*, OPERCULUM, × 85, WITH ITS TWO SMALL MUSCULAR ATTACHMENTS. *B–D*, MANDIBLES, × 85, *B*, OF A SMALL INTERZOOECIAL AVICULARIUM, *C*, OF AN ABNORMAL INTERZOOECIAL AVICULARIUM; AND *D*, OF AN INTERZOOECIAL AVICULARIUM WITH DUCK-BILL FORM

Measurements.—

Apertura $\begin{cases} ha = 0.16 \text{ mm.} \\ la = 0.14 \text{ mm.} \end{cases}$ Large avicularia $\begin{cases} Lav = 0.60 \text{ mm.} \\ lav = 0.30 \text{ mm.} \end{cases}$

Affinities.—The interzooecial avicularia are large or small; our measurements are the maximum and are those of the avicularian chamber itself and not that of the orifice.

The avicularian beak measures 0.50 by 0.20 mm. on the well-preserved specimens. It much resembles in this feature, as also in the frontal, with areolar pores, *Cellepora eatoniensis* Busk, 1881. *Osthimosia anatina* differs in its perforated ovicells (and not smooth according to Waters, 1904). It differs again from *Cellepora cylindriformis* Busk, 1884, from the Cape of Good Hope and from Australia, which it resembles very much in its avicularium and its perforated ovicell, by the presence of areolar pores. The areolar pores not only are hidden by the ectocyst, but they are not visible on the incompletely calcified living specimens. A single specimen preserved the base which is orbicular and little expanded. The substratum is unknown.

The genus *Schismopora* and *Osthimosa* are poorly defined by the perforation of the ovicells; the frontal calcification appears to furnish the better distinctive character.

Biology.—We have observed specimens living and ovicelled in April, 1888.

Occurrence.—Galapagos Islands, D. 2813 and D. 2815.

Cotypes.—Cat. Nos. 8516, 8517, U.S.N.M.

Genus HIPPOPORIDRA Canu and Bassler, 1927

HIPPOPORIDRA GRANULOSA, new species

Plate 8, Figures 1, 2

Description.—The zoarium incrusts shells. The zooecia are oriented or cumulate. The oriented zooecia are distinct, separated by a furrow, ovoid, a little elongated; the frontal is quite granular, convex, surrounded by scattered areolar pores. The aperture is small, elongated, and formed of a large circular anter and of a very small rounded poster, surmounted by six distal spines. In the vicinity of the aperture there is sometimes a small avicularium of inconstant form and position. The cumulate zooecia are erect and form very salient verrucosities. The operculum bears two sinuous bands.

Measurements.—

$$\text{Apertura}\begin{cases} ha=0.12 \text{ mm.} \\ la=0.07\text{–}0.09 \text{ mm.}\end{cases} \qquad \text{Zooecia}\begin{cases} Lz=0.40\text{–}0.50 \text{ mm.} \\ lz=0.30\text{–}0.35 \text{ mm.}\end{cases}$$

Variations.—The width of the aperture is rather variable; it has in consequence a great variability in the operculum. On a dozen of opercula visible in our preparation not one is exactly similar to the other, but all, however, have their two characteristic sinuous bands. There are no dietellae.

Affinities.—This species is very well characterized by its frontal granules and the large number of oriented zooecia. We have not observed the large interzooecial avicularia as in *Hippoporidra brancoensis* Calvet, 1907, and *Hippoporidra edax* Smitt, 1873.

Our specimen was living but very incomplete, since it did not show an ovicell. It incrusts the two sides of a shell; the cumulate cells are arranged only on the edge of the shell. The latter then must have been attached to some more or less floating tuft and did not live on the bottom when dredged.

Occurrence.—Galapagos Islands, D. 2813.

Holotype.—Cat. No. 8518, U.S.N.M.

Genus HIPPOTREMA Canu and Bassler, 1927

HIPPOTREMA(?) SPICULIFERA, new species

Plate 8, Figures 3–5

Description.—The zoarium is free, cylindrical, branching or in thick fronds. The zooecia are cumulate, small, oblique; the frontal

bears scattered pores and three to four very salient spicules, erect, almost cylindrical. The aperture is elliptical, little elongated; two small cardelles separate a large anter from a small poster of the same width; three to five long and very fine spines. The interzooecial avicularia are long, large, salient with pivot; the mandible is very narrow.

Measurements.—

$$\text{Apertura}\begin{cases} ha=0.12 \text{ mm.} \\ la=0.10 \text{ mm.} \end{cases} \quad \text{Avicularia}\begin{cases} Lav=0.20\text{–}0.30 \text{ mm.} \\ lav=0.14\text{–}0.16 \text{ mm.} \end{cases}$$

Diameter of spicules=0.04–0.06 mm.

Structure.—Our colonies do not have their base. The ectocyst is thick and hides the frontal pores. The large avicularia are oriented in every direction; they are numerous at places and rare at others. The mandible is narrow, longitudinally convex, which makes it appear much in a special preparation.

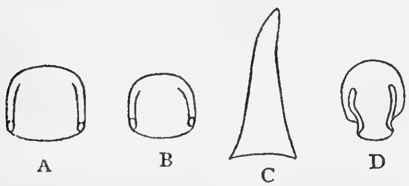


FIGURE 10.—HIPPOTREMA AND HIPPOPORIDRA, CANU AND BASSLER, 1927. *A–C*, HIPPOTREMA SPICULIFERA, NEW SPECIES. *A, B*, OPERCULA, × 85, AND *C*, MANDIBLE OF AN AVICULARIUM, × 85. *D*, OPERCULUM, × 85 OF HIPPOPORIDRA GRANULOSA, NEW SPECIES

The spicules form an ornamental system particular to this species. They are sometimes hollow. The operculum has the form of the aperture. Two lucidas indicate the place of the cardelles; there are two lateral rectilinear bands very near the border. It is thick, much chitinized, light colored.

Affinities.—This is a very original species with no analogy with the known species. It differs from *Lepralia brancoensis* Calvet, 1907, from the Cape Verde Islands in the presence of frontal spicules and in a different operculum with no lateral contraction.

Biology.—Our specimens were living but not ovicelled on April 7–9, 1888.

Occurrence.—Galapagos Islands, D. 2813 and D. 2815.

Cotypes.—Cat. No. 8519, U.S.N.M.

Suborder HEXAPAGONA Canu and Bassler, 1927

Family CHAPERIIDAE Jullien, 1888

Genus CHAPERIA Jullien, 1881

CHAPERIA CONDYLATA, new species

Plate 9, Figures 1–3

Description.—The zoarium incrusts dead bryozoa and nullipores. The zooecia are distinct, separated by a salient mural rim, ogival, with transverse aspect. The mural rim bears six large distal spines with a black articulation. The cryptocyst is deep and smooth and

supports an avicularium placed in a proximal angle. The opesium is suborbicular and restricted laterally by two large condyles. The ovicell is large, salient, smooth, marginated proximally, with a very large orifice; it is often decorated by one or two avicularia in which the beak is always turned inferiorily. The avicularia are long, thin, triangular, without pivot; when there is one only it is placed transversely, but when there are two their beak is oriented distally.

Measurements.—

Opesium $\begin{cases} ho = 0.15\text{–}0.20 \text{ mm.} \\ lo = 0.20\text{–}0.23 \text{ mm.} \end{cases}$ Zooecium $\begin{matrix} Lz = 0.40\text{–}0.40 \text{ mm.} \\ lz = 0.45 \text{ mm.} \end{matrix}$

Avicularium $\begin{cases} Lav = 0.20\text{–}0.25 \text{ mm.} \\ lav = 0.10 \text{ mm.} \end{cases}$

Affinities.—In its exterior aspect this resembles *Chaperia annulus* Manzoni, 1875, very much, but differs from it in the presence of two condyles to the opesium, in having six spines and not four, in the simple spines (and never bifurcated), in the avicularia irregularly oriented and never placed in the median axis of the zooecium, and in the frequent occurrence of two avicularia on the ovicell. It differs from *Chaperia galeata* Busk, 1854, in the absence of bifurcated spines. Moreover, this species is rather poorly known because of the erroneous interpretations of the figures by the authors. Its bibliography must be revised entirely.

Biology.—The colonies are a deep purple or a beautiful red violet. In life they are always covered with dirt and never have the beautiful aspect of the published figures. Their numerous spines retain a large number of small particles of all kinds, calcareous, argillaceous, and sandy, with small foraminifera developed among them. The operculum itself is not free. The chitinous sponges erect their first filaments here which seems to indicate a much restrained mobility of the spines. Also the immediate determination is absolutely impossible, for an army of small dirty sticks only is visible. Washing in Javelle water is absolutely necessary in order to discover the other characters, whereupon the cells appear with an incomparable richness of ornamentation, the usual indication of calm waters.

The action of the avicularium is absolutely incomprehensible and their inversion on the ovicells does not give us any information.

Occurrence.—Galapagos Islands, D. 2815.

Cotypes.—Cat. No. 8250, U.S.N.M.

Family MAMILLOPORIDAE Canu and Bassler, 1927

Genus MAMILLOPORA Smitt, 1873

MAMILLOPORA CUPULA Smitt, 1873

We have observed 15 very small dead colonies. We have studied equally small colonies from the Gulf of Mexico, but they are much

more rare. The species has apparently degenerated in the Pacific since the formation of the Isthmus of Panama.

Occurrence.—Galapagos Islands, D. 2813.

Cat. No. 8521, U.S.N.M.

Order CYCLOSTOMATA Busk

Family DIASTOPORIDAE Gregory, 1899

Forma PROBOSCINA Audouin, 1826

PROBOSCINA LAMELLIFERA, new species

Plate 11, Figures 1, 2

Description.—The zoarium incrusts shells and is formed of sinuous branches joined together by a smooth calcareous lamella. The tubes are indistinct, short, serrated, and terminated by a long peristomie perpendicular to the zoarial plane.

Measurements.—Diameter or orifice, 0.12 mm.; diameter of peristome, 0.16–0.18 mm.; internal separation of tubes, 0.20–0.30 mm.; width of branches, 1.5 mm.

Affinities.—This arrangement of the branches on a calcareous lamella, cellular because of decortication, is quite special and very characteristic. It has been observed only on the fossils, notably on *Idmonea hagenowi* Sharpe, 1854, from the English Cenomanian, and on *Tubulipora biduplicata* Waters, 1887, from the Miocene of New Zealand. It is interesting to rediscover in the recent seas a feature observed in the ancient seas, permitting an explanation of the structure. Unfortunately the number of our specimens was too small for a detailed study by thin sections.

It is necessary to note the special arrangement of the peristomes; they are oriented not longitudinally as in true *Proboscina* but obliquely toward the zoarial margins as in *Idmonea.*

Occurrence.—Galapagos Islands, D. 2813.

Holotype.—Cat. No. 8522, U.S.N.M.

Family ONCOUSOECIIDAE Canu, 1918

Genus ONCOUSOECIA Canu, 1918

ONCOUSOECIA (PROBOSCINA) MAJOR Johnston, 1847

1884. *Stomatopora major* Hincks, Polyzoa of Queen Charlotte Islands, Annals and Magazine of Natural History, ser. 5, vol. 10, p. 204 (sep. 33).

1889. *Stomatopora major* Jelly, A synonymic Catalogue of Marine Bryozoa, p. 257 (bibliography).

1900. *Tubulipora* (*Stomatopora*) *major* Neviani, Bryozoi neogenici della Calabrie, Paleontographica italica, vol. 6, p. 235 (sep. 121) (local bibliography).

1905. *Tubulipora* (*Stomatopora*) *major* NEVIANI, Bryozoi fossili di Carrubare, Calabria, Bolletino della Societe geologica italiana, vol. 23, p. 548 (sep. 48), fig. 18 (ovicell).

1907. *Stomatopora major* CALVET, Bryozoaires des Expeditions scientifique du *Travailleur* et du *Talisman*, p. 461 (bibliography).

1912. *Stomatopora major* NORDGAARD, Revision av universitets museets samling av norske Bryozoer. Kgl. norske Videnskabers Selskabs Skriften, No. 3, p. 14.

1923. *Stomatopora major* H. and E. O'DONOGHUE, A preliminary list of Polyzoa from the Vancouver Islands Region. Contributions to Canadian Biology, new series, vol. 1, p. 11.

Measurements.—Diameter of orifice, 0.14–0.18 mm.; diameter of peristome, 0.20–0.24 mm.; distance of orifices, 0.80–1.20 mm.; diameter of tubes, 0.30–0.40 (max.) mm.

Variations.—The peristomie (that is to say, the portion free from the tubes) is here very erect and almost perpendicular to the rampant surface. Calvet has noted the variations. On the rampant portion the tubes are separated by a furrow or by a little salient thread. The peristome is thin or thick.

The branches are arched and formed of 1, 2, or 3 rows of tubes. Our specimens were dead and incrusted shells and Cellepores.

Biology.—This species has been observed in the Pacific by only two authors. Hincks (Queen Charlotte Island) and O'Donoghue (Northumberland Channel). Its geographic extension appears rather great, since we have found it in the equatorial belt.

In the Atlantic region it is a species of the temperate zone and of the Mediterranean. But it extends, however, almost to the Cape Verde Islands in the equatorial zone, so that its discovery in the Galapagos Islands is not astonishing. Moreover its paleontologic distribution justifies its geographic extension. However, the fossils found by Waters, 1887, in New Zealand appear too small. The diameter of 0.12 mm. is observed sometimes on certain recent colonies, but always among the much larger tubes. The species lives very rarely on algae.

Occurrence.—Galapagos Islands, D. 2813.

Geographic distribution.—Atlantic: shores of England, 23–170 fathoms; Gulf of Gascogny, 135–180 meters; English Channel to Roscof; shores of Norway at Bergen and at Bongostrommen; Cape Spartel, Morocco, 717 meters; Pico-Fayol; Azores, 80–130 meters; Saint Vincent, Cape Verde Islands, 21 meters. Mediterranean: Corsica on the coast from Rousse Island and to Bastia, 40 meters; Villefranche-sur-Mer; Toulon. Pacific: Queen Charlotte Islands, Gabriola and Northumberland Channel, 15–40 fathoms.

Geologic distribution.—Miocene, Astian, Sicilian and Quaternary of Italy.

Cat. No. 8523, U.S.N.M.

Family MECYNOECIIDAE Canu, 1918

Genus MICROECIA Canu, 1918

MICROECIA TUBIABORTIVA, new species

Plate 8, Figures 6, 7

Description.—The zoarium incrusts shells. The primitive Berenicea form gives rise to palmate or rectilinear fronds. The tubes are little distinct, very little convex, smooth, irregularly arranged; the peristomies are very short and oblique. The orifice is orbicular; the peristome is thin. Aborted tubes, visible or invisible, form irregular spots on the colonial surface. The ovicell is small, orbicular, little convex, perforated by a small oeciopore.

Measurements.—Diameter of orifice, 0.10 mm.; diameter of peristome, 0.14 mm.; distance of orifices, 0.44 mm. (variable); separation of orifices, 0.16–0.24 mm.

Affinities.—The colony is very irregular in appearance because the fronds rising from the primitive *Berenicea* form are irregular in dimensions. This mode of ramification of the branches is rather rare and very well characterizes this species.

The large, smooth, irregular spaces distributed between the tubes on the zoarial surface are occupied in reality by aborted tubes. They are altogether invisible or simply indicated by salient threads or, more rarely, visible but closed by a lamella. We are absolutely ignorant of the utility of this structure.

Occurrence.—Galapagos Islands, D. 2813.

Holotype.—Cat. No. 8524, U.S.N.M.

Family PLAGIOECIIDAE Canu, 1918

Genus PLAGIOECIA Canu, 1918

PLAGIOECIA LACTEA Calvet, 1903, variety

Plate 11, Figures 7, 8

1903. *Diastopora lactea* CALVET in JULLIEN and CALVET, Bryozoaires provenant des Campagnes de l'Hirondelle, p. 163, pl. 18, fig. 4 (Gulf of Gascogny, 43° 37′ N.; long. 90° 27′ 300 meters, on hydroids).

1907. *Diastopora lactea* CALVET, Bryozoaires des expeditions scientifiques du *Travailleur* et du *Talisman*, p. 466 (Cape Spadel, Morocco, 717 meters on *Lophohelia*).

Measurements.—Diameter of orifice, 0.08 mm.; diameter of peristome, 0.10–0.12 mm.; distance of tubes, 0.40–0.50 mm.; external separation of tubes, 0.40–0.50 mm.

Affinities.—Our specimen differs from those from the Gulf of Gascogny in the less numerous cells on the border and in the presence of

tubes closed by a calcareous lamella with median tubule. The dimensions are identical, the colony is also free and pedunculated, and we were able to observe the same concentric striae and the same ovicells.

The same closures with median tubules are commonly observed in *Plagioecia sarniensis* Norman, 1864; but the tubes are much more slender than in our species.

It is often very difficult to discover characters really specific in the Cyclostomata, and we do not believe a new species should be created with characters so little different from those assigned by Calvet to his *Diastopora lactea.*

Occurrence.—Galapagos Islands, D. 2813.

Plesiotypes.—Cat. No. 8525, U.S.N.M.

Family DIAPEROECIIDAE Canu, 1918

Genus DIAPEROECIA Canu, 1918

DIAPEROECIA STRIATULA, new species

Plate 11, Figures 3–6

Description.—The zoarium is orbicular and incrusts shells or algæ. The tubes are indistinct, immersed in a concentrically striated crust. The peristomie is salient, short, very oblique; the orifice is orbicular or somewhat elliptical; the peristome is thin. The ovicell is a long, transverse, salient sack perforated by tubes, more often placed near the zoarial margin.

Measurements.—Diameter of orifice, 0.08 mm.; diameter of peristome, 0.12 mm.; distance of orifices, 0.30–0.40 mm.; internal separation of orifices, 0.30–0.34 mm.

Affinities.—This species bears concentric striae like *Microecia suborbicularis*, with tubes closed by a lamella with tubule like *Plagioecia sarniensis* Norman, 1864, and closely approximated cells as in *Diastopora congesta* Busk, 1875. It is nevertheless distinctly different from these three species in the ensemble of its characters and In its measurements.

If the substratum is very regular, the peristomies are of equal size; they are on the contrary very irregular if the substratum is irregular and much elongated in the more sheltered parts. This is the rule, moreover, in all the Cyclostomata.

The basal lamella is broad, very fragile, and is frequently lacking on the dead colonies.

This species is clearly distinct from *Plagioecia lactea* Calvet, 1903, not only in the nature of its ovicell but also in the more closely arranged orifices. This form of ovicell perforated by the tubes is rather common both in the recent seas and in the fossils since the Cretaceous.

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It is deprived of an oeciostome, and we do not still understand the method of escape of the larvae. It may be necessary to create a special genus, for in true *Diaperoecia* there is a fine submedian and salient oeciostome.

Occurrence.—Galapagos Islands, D. 2813.

Cotypes.—Cat. No. 8526, U.S.N.M.

DIAPEROECIA SUBPAPYRACEA, new species

Plate 12, Figures 1–4

Description.—The zooecium is discoidal, simple or composite, surrounded by a very thick, wide, and porous margin. The tubes are little distinct, with a short and very oblique peristomie; the peristomes are thick, round, or oval, very close together, arranged in quincunx on the young colonies but in radial very irregular rows on the old zoaria. The ovicell is located on the zoarial margin; it is long, convex, fusiform, perforated by tubes, often closed by a calcareous lamella.

Measurements.—Diameter of orifice, 0.08 mm.; diameter of peristome, 0.11 mm.; maximum diameter of colonies, 7.5 mm.

Affinities.—This species is the perfect representation of *Actinopora papyracea* D'Orbigny, 1852,[1] from the Maastrichtian of Meudon near Paris. If we can not make the comparison complete, it is because the ovicell of the fossil is unknown.

Biology.—When two colonies are coalescent they never cover each other but arise from two different larvae. It is not rare, even in the Cheilostomata to see many colonies on the same shell for they arise from the same swarm of larvae which seem to travel together.

It is most remarkable to note, as in Figure 1, larvae from an unknown colony fix themselves on the same substratum at almost the same place so that colonies are superposed. On our figures we can note that the larvae arrived here for five years or seasons with an almost mathematical precision. Moreover, in order that there be superposition, it is necessary that the inferior zoarium be dead. Such a small disk is born, grows, and dies the same year. We have here a good example to evaluate the length of the zoarial life. This species is not only interesting because of its archaic aspect but also it reveals the voyage of the larvae in swarms and the duration of the zoarial development.

The ovicell belongs to the group of *Diaperoecia* without oeciostome.

Occurrence.—Galapagos Islands, D. 2813.

Cotypes.—Cat. No. 8527, U.S.N.M.

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[1] Bryoz. Cret., pl. 643, figs. 12–14.

DIAPEROECIA MEANDRINA, new species

Plate 12, Figures 5–9

Description.—The zoarium is free, formed of bilamellar, reticulated fronds, forming a meandriform ensemble with all the basal lamellæ oriented superiorily and exteriorily. The tubes are little distinct, striated transversely; the peristomes are thin, elliptical or orbicular, very little salient on the fronds, very long in the vicinity of the basal lamella. The ovicell is a long, elongated sack, elliptical, very

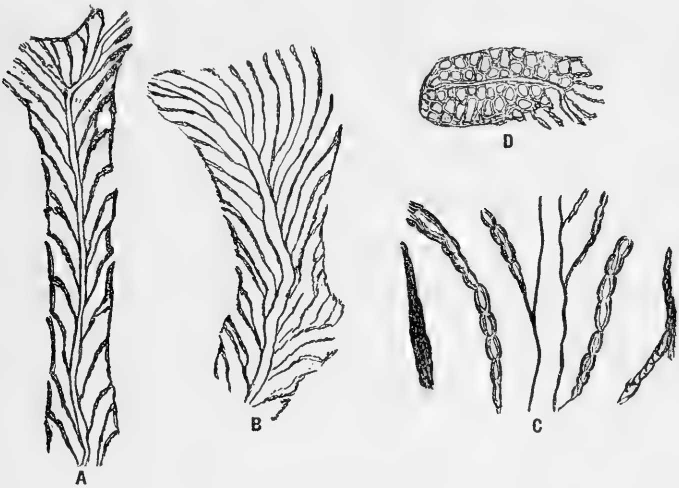

FIGURE 11.—DIAPEROECIA MEANDRINA, NEW SPECIES. *A*, LONGITUDINAL SECTION, × 16, THROUGH A BRANCH MADE IN THE ZOARIAL AXIS BUT NOT PARALLEL TO THE DIRECTION OF THE TUBES. THE GEMMATION HAS THE APPEARANCE OF TRIPARIETAL ALONE. *B*, LONGITUDINAL SECTION, × 18, MADE IN THE DIRECTION OF CERTAIN TUBES WHERE THE DORSAL GEMMATION IS SOMEWHAT APPARENT. *C*, PORTION OF THE SAME SECTION, × 55, SHOWING THE MONILIFORM STRUCTURE OF THE WALL. *D*, TRANSVERSE SECTION, × 16, EXHIBITING THE DOUBLE MEDIAN LAMELLA AND THE TWO BERENICOID LOBES GROWING BACK TO BACK AND BECOMING FREE. THE TUBES ARE CYLINDRICAL AND SEPARATED BY A CALCAREOUS TISSUE

salient, perforated by the tubes, arranged parallel to the zoarial margin.

Structure.—The colony is a true *Reticulipora* so often observed in the Cretaceous formations. The ovicells alone are different.[2] The development of the zoarium is identical with that of *Diaperoecia dorsalis* Waters, 1879, of which we have indicated the different phases in 1925.[3] It is at first sight an ordinary *Berenicea* with two lobes developing in a different plane remaining back to back and their median lamella oriented superiorily and developed laterally.

The branches are formed in an identical fashion and the basal lamella, now median, is quite visible in our figure. As they are very

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[2] Canu and Bassler, Les Bryozoaires du Maroc et du Mauritanie, Memoires de la National Museum, vol. 61, p. 29, pl. 5, figs. 9–12.
[3] Idem, p. 67, pl. 9, figs. 1–16.

compressed, their dorsal—that is to say, the side opposite the basal lamella—is very narrow and the tubes there are visible in part of their length. The peristomes are grouped in transverse rows but oriented obliquely in the direction of the latter. The tubes in their length are curved almost at right angles to the basal lamella.

The longitudinal section indicates cylindrical tubes with triparietal gemmation. But it is a deceiving indication, this section not being made in the same direction as the tubes. The mode of gemmation is indicated, on the contrary, by the meridional section and is in reality dorsal as in the other Diastoporas. The walls of the tubes are vesicular as in *Heteropora claviformis* Waters, 1904. The base of a rather large colony is small, suborbicular; it is the primitive Berenicea form in which the concentric striae may be seen (fig. 6). The first branches arise a little farther away on the same substratum in order to give solidity to the ensemble. In reality *Reticulipora* is formed only of free branches of an encrusting colony. We have not yet observed the oeciostome on the ovicell of this species. It is not yet a true *Diaperoecia.*

Occurrence.—Galapagos Islands, D. 2815.

Cotypes.—Cat. No. 8528, U.S.N.M.

DIAPEROECIA FLABELLATA Canu and Bassler, 1923

1923. *Diaperoecia flabellata* CANU and BASSLER, Later Tertiary and Quaternary Bryozoa of North America, Bull. U. S. Nat. Mus. No. 125, p. 202, pl. 13, figs. 18, 19.

Our specimens are simple, bifurcated, dead fragments. They are ovicelled. The tubes are grouped in linear series somewhat more accentuated than on our figures of 1923. This is a typical *Diaperoecia* with oeciostome on the nonmarginal ovicell.

Occurrence.—Galapagos Islands, D. 2813.

Cat. No. 8529, U.S.N.M.

Family TUBULIPORIDAE Johnston, 1838

Genus TUBULIPORA Lamark, 1816

TUBULIPORA, species

Plate 14, Figure 6

The small figured specimen incrusts a shell. It does not coincide exactly with any published figure. The bundles have three tubes at most. The peristome measures approximately 0.12 mm. and the orifice 0.08 mm. The oeciostome is a tube smaller than the others, little salient with transverse orifice.

Occurrence.—Galapagos Islands, D. 2815.

TUBULIPORA TUBULIFERA Lamouroux, 1821

Plate 14, Figures 1–4

1821. *Obelia tubulifera* LAMOUROUX, Exposition methodique des genres de Polypiers, p. 80, pl. 8, fig. 8 (Mediterranean).

1870. *Idmonea serpens* MANZONI, Bryozoi fossili italiani; quarto contribuzione. Sitz. der k. Akademie der Wissenschaften, p. 27, pl. 6, fig. 22 (linear form) (Sicilian of Italy).

1905. *Idmonea serpens* NEVIANI, Bryozoi fossili di Carrubare, Bollettino Societa geologica Italiana, vol. 23, p. 547 (45), fig. 16 (ovicell) (Sicilian of Italy).

1922. *Idmonea serpens* WATERS, On mediterranian *Tervia* and *Idmonea*, Annals and Magazine of Natural History, ser. 9, vol. 10, p. 13, pl. 2, figs. 3, 5, 8, 10 (ovicelli) (Naples, Rapallo, Menton, San Remo, Saint-Raphael, on *Posidonia* and algæ).

1925. *Idmonea serpens* CANU and BASSLER, Les Bryozoaires du Maroc et de Mauritanie, Mémoires do la Société des Sciences naturelles du Maroc, vol. 10, p. 68 (shores of Morocco).

Measurements.—Diameter of orifice, 0.08 mm.; width of lines (peristome), 0.12–0.14 mm.; interior separation, 0.20–0.30 mm.; diameter of oeciopore, 0.08 mm.; diameter of oeciostome, 0.14 mm.; number of tubes to the fascicle, 4; diameter of protoecium, 0.16 mm. (Waters).

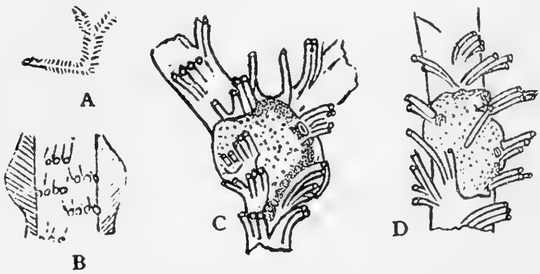


FIGURE 12.—TUBULIPORA TUBULIFERA LAMOUROUX. *A*, EXAMPLE, × 2. *B*, SKETCH SHOWING SELVAGE. *C*, SPECIMEN WITH OVICELL, × 12. *D*, AN OVICELLED EXAMPLE SHOWING TWO OECIOSTOMES. RECENT, ST. RAPHAEL AND NAPLES (AFTER WATERS, 1922), AS T. SERPENS)

On the dorsal the tubes are cylindrical. The oeciopore is elliptical, nonsalient; it is the first tube of a fascicle. The figure of Neviani, 1905, is perfectly correct, and we reproduce it. The tubes of the same fascicle are not always rigorously adjacent; they appear then interrupted. The micrometric measurements taken from the figures of Waters, 1922, correspond almost to ours.

The colonies are very variable and exhibit triangular, rounded, and bifurcated lobes; the linear forms are short and rare.

Affinities.—This species differs from *Tubulipora liliacea* Harmer, 1898, in its smaller orifice (0.08 mm. and not 0.10 mm.), in its interrupted fascicles, in the elliptical form of its oeciostome, and its smaller and more slender colonies.

The specimen figured by Busk, 1875,[4] shows analogous dimensions, and it is probably the Mediterranean species.

[4] Catalog Marine Bryozoa, vol. 2, p. 29, pl. 22.

We have reviewed the specimens collected in the Atlantic region. With the aspect of the figure of *Tubulipora liliacea* Harmer, 1898, it shows the small micrometric measurements of the Mediterranean species. It is not at all the Atlantic species dredged in the more northern regions.

Historical.—Harmer, 1898 (p. 96), was the first to separate *Obelia tubulifera Lamouroux*, 1821, from the long synonymy erroneously given by Smitt in 1867 and by Miss Jelly in 1889, but he believed it identical with his *Tubulipora phalangea*, which in our opinion is incorrect, as the oeciostomes are totally different.

The older authors made no use of micrometric measurements, and as a result they made a large number of erroneous determinations which are often very difficult to correct when one can not see the figured specimens. All the specialists now know that perfectly distinct species of bryozoa can have absolutely identical zoarial aspects.

Biology.—*Tubulipora tubulifera* Lamouroux, 1821, lives principally on algae and is therefore a floating species. It is quite prolific and its small colonies are often very numerous on the same substratum. When the latter is dead they persist because of their calcareous nature as free forms, but they soon die. The bathymetric indications furnished by the specimens dredged dead have no value.

Occurrence.—Alascio and Porto d'Anzio, Italy.

TUBULIPORA, species

Plate 14, Figure 5

The small specimen figured incrusts a shell. Its oeciostome is identical with that of the first species we have noted here. The micrometric measurements are also very close, but the fascicles are rare and bear only two tubes. The colony is not flabellate.

We can not be certain that these small colonies are completely developed. Moreover, in this important genus, in which the species are quite variable, we have not yet an absolute criterion for the limitation of the species.

TUBULIPORA LILIACEA Harmer, 1898

Plate 13, Figures 1–10

1898. *Tubulipora liliacea* Harmer, On the development of *Tubulipora*, Quarterly Journal Microscopical Science, vol. 41, p. 90, pl. 8, figs. 7–9 (Trondjhem, Liverpool, St. Andrews Bay, on hydroids).

1903. *Tubulipora liliacea* Nordgaard, Die Bryozoen, des westlichen Norwegens Meeresfauna von Bergen, p. 99 (Hjeltefjord, 6–20 meters; Skjaergaard, 30–40 meters).

1905. *Tubulipora liliacea* NORDGAARD, Hydrographical and biological investigations in Norwegian fiords, Bryozoa, Bergen Museum, p. 173 (Sag Fiord, 200 meters, on branches of *Isidella hippuris;* Malangen, 100–200 meters).
1912. *Tubulipora liliacea* NORDGAARD, Revision av universitets samling av norske Bryozoer. Kgl norske Videnskabers Selskabs Skriften, no. 3, p. 14, (Riser; Glesvaer; Manger; Flors; Bognostrommen; Beran; Skarnsund, Bodo, Hammerfest).
1912. *Tubulipora liliacea* OSBURN, Bryozoa of Woods Hole region, Bulletin Bureau of Fisheries, vol. 30, p. 217, pl. 20, fig. 10 (Vineyard Sound, Sow and Pigs Reef; Buzzards Bay near Robinson Hole; Woods Hole, shallow water, 4–24 meters, on algae, hydroids, *Bugula*, shells).
1918. *Tubulipora liliacea* NORDGAARD, Bryozoa from the arctic regions, Tromso Museums Aarshefter, vol. 40, p. 17 (between Lodingen and Kjollefjord in Finmark, 30–200 meters on hydroids).

Measurements.—Diameter of orifice, 0.12–0.14 mm., diameter of peristome, 0.16–0.20 mm.; internal distance (between the fascicles), 0.20–0.30 mm.; diameter of protoecium, 0.10–0.16 mm.; diameter of oeciostome, 0.16 mm; number of tubes, 5 to 8.

Structure and variations.—We have been able to examine a certain number of specimens of diverse origin, corresponding rigorously to the figures of Harmer, 1898, and have given photographs in order to prove the homogeneity of their characters. The latter are essentially (1) violet color of the colonies, (2) the slight separation of the fascicles, (3) the continuity of the fascicles, never interrupted, (4) the great thickness of the peristomes, and (5) the presence of an oeciostome of the same diameter as the tubes but arranged obliquely.

A specimen dredged from Rokall Bank, Scotland, shows a linear basal portion on which the separation of the fascicles is somewhat greater (0.40 mm.) The other specimens were flabellate and bifurcated.

Another specimen from the Atlantic dredged at LeCroissic, France, is composed of four rectilinear branches arranged in a cross. Its protoecium is very small, little apparent, with a diameter of 0.10 mm.

The specimen dredged in the English Channel at Etretat, France, is claviform. Its protoecium is a little swollen and measures 0.16 mm. in diameter.

All these characters are visible on the excellent figure of Osburn, 1910 (pl. 20, fig. 10), representing a specimen from Vineyard Sound, Mass. The only difference is the isolation of a certain number of tubes on the distal portion of the colony. But in the eastern Atlantic we have not observed specimens so young. Moreover the author did not indicate the enlargement of his figure. The oeciostome figured is that of *Tubulipora liliacea* and not *T. tubulifera* Lamouroux, 1821. The Galapagos specimens are not exactly identical, as the

fascicles are not as wide and the oeciostome is larger. We consider them provisionally as a new variety, *tenuis*.

Affinities.—*Tubulipora liliacea* Harmer, 1898, is a species of the northern part of the temperate zone and does not appear to descend as far as the Gulf of Gascogny. It is there replaced in the Atlantic and in the Mediterranean by *Tubulipora tubulifera* Lamouroux, 1821, which is a species more slender and less vigorous. As it has been confused with *Tubulipora serpens* Linnaeus, 1758, we give a new description.

In his synonymy of *Tubulipora liliacea* Pallas, 1756, Harmer adds *Tubulipora serpens* Busk, 1875, Smitt, 1867, and Hincks, 1880. It is difficult for us to accept this conclusion, as Busk's figure of 1875, in its micrometric measurements, indicates more the Mediterranean species. The figures of Smitt, 1867, and of Hincks, 1880, indicate a different species characterized by a more linear zoarial form and especially by a greater internal separation of the fascicles, because this varies from 0.40 mm. to 0.60 mm. Moreover, there are never more than four tubes to the fascicle. In order not to change the nomenclature perhaps it would be well to consider this third species as the true *Tubulipora serpens* Linnaeus, 1758. We have not been able to secure a sufficient number of specimens for an exact study, but it is certain that our photographs do not have any relationship with those published by Hincks, Busk, and Smitt.

Biology.—All our specimens of *Tubulipora liliacea* (Pallas) Harmer, incrust shells. A single specimen from Wissant (Pas-de-Calais, France) incrusts a *Sertularia*. This is then not a floating species like the Mediterranean species and the species of Smitt-Hincks. Finally, observed on a solid substratum, it furnishes good bathymetric indications.

Occurrence.—Galapagos Islands, D. 2815.

Plesiotypes.—Cat. No. 8530, U.S.N.M.

Family LICHENOPORIDAE Smitt, 1866

Genus LICHENOPORA Defrance, 1823

LICHENOPORA RADIATA Savigny-Audouin, 1826

1923. *Lichenopora radiata* Canu and Bassler, North American Later Tertiary and Quaternary Bryozoa, p. 204, pl. 44, fig. 10. (Bibliography, geologic and geographic distribution.)

We have found only a single dead specimen. It is free and very well preserved.

Biology.—This species is another evidence of the ancient communication between the Atlantic and the Pacific, for we have discovered it also in the Gulf of Mexico and in the Philippines.

It lives rather frequently on floating algæ, so that the bathymetric indications which it can furnish are only relative.

Occurrence.—Galapagos Islands, D. 2813.

Cat. No. 8531, U.S.N.M.

DEFRANCIA STELLATA Reuss, 1847

Plate 14, Figures 7–12

1847. *Defrancia stellata* REUSS, Die fossilen polyparien des Wiener Tertiarbeckens, Haidinger's naturwissenschaftliche Abhandlungen, vol. 2, p. 37, pl. 6, fig. 2.

1877. *Defrancia stellata* MANZONI, I Briozoi fossili del Miocene d'Austria ed Ungheria, II parte, Denkschriften der math. natur. Classe der k. Akademie der Wissenschaften, vol. 33, p. 16, pl. 16, fig. 63.

Structure.—It is quite remarkable to rediscover in the recent seas this European fossil. We have been able to compare the Galapagos specimens with different fossil specimens from the Canu collection, and the identity of the micrometric measurements is as exact as possible.

In order to show the exactness of our determination we reproduce at the same magnification fossil specimens. The only appreciable difference is in the separation of the fascicles, which appears to be slightly larger on the recent specimens.

The specimen from the Lower Miocene of El Amran, Algeria, shows manifest traces of the basal lamella around each subcolony. The orifice of the tubes is a little smaller (0.06 mm.). The specimens found in the Friren collection are simply marked "Helvetian"; the exact bed is unknown. The fascicles are a little narrower, measuring 0.16 mm.

The micrometric measurements of the specimen from the Sahelian of Oran are exactly those shown in specimens from Galapagos.

The entire absence of the solid substratum indicates a special adaptation to floating life. Indeed most of the Galapagos specimens are attached to floating cellepores. The following table gives a summary of the micrometric measurements:

	Diameter of orifice	Width of fascicles	Diameter of intermediate pores
	Mm.	*Mm.*	*Mm.*
Recent (Galapagos)	0. 08	0. 18–0. 20	0. 06–0. 08
Burdigalian	0. 06	0. 20	0. 08
Helvetian	0. 06	0. 16	0. 06–0. 08
Sahelian	0. 08	0. 16–0. 20	0. 08

It is possible that the recent species is different from the fossil one, but in the present state of knowledge it is impossible to estimate the importance of the separation of the fascicles on colonies. The discovery of the ovicells would give perhaps a better character of differentiation.

Our specimens are attached to corals, to nullipores, and to Cellepores. Their color is violet. They are formed of superposed subcolonies, forming short bifurcated branches. The superior subcolony only remained alive; it is bordered by a wide, smooth basal lamella, free or covering the inferior subcolony. The tubes are formed of two or three rows of polygonal tubes; they are little salient and arranged laterally. The cancelli(?) are numerous, with a diameter almost equal to that of the tubes; they occupy all the superior part of the colony and the space between the fascicles. On the dead slightly worn specimens the fascicles are more visible and they then resemble *Cerioporas*.

As the ovicell is not known, it is useless to attempt the proper classification of this species, and it is preferable to leave it under the primitive name. The rare simple colonies have the aspect of *Lichenopora* and the composite colonies have that of *Tholopora* or *Domopora*.

The synonymy given by Miss Jelly (p. 86) for *Domopora stellata* is absolutely false. This author has confused the present species with *Coronopora truncata* Fleming, 1828, which is a boreal species of the Tubuliporidae and with another species of Jameson.

Occurrence.—Galapagos Islands, D. 2815.

Plesiotypes.—Cat. No. 8532, U.S.N.M.

CAVARIA PRAESENS, new species

Plate 9, Figures 7–9

Description.—The zoarium incrusts Cellepores and shells; it is surrounded by a wide smooth, basal lamella, and emits short, cylindrical fragments terminated by irregular pores and divided into two parts by a very little salient diametrical lamella (basal lamella). The tubes (invisible exteriorily) are in section, cylindrical, with dorsal gemmation on the basal lamella covered at the extremity of their length with moniliform walls. The peristome is thin, little salient. The tubes are separated by irregular ramified mesopores, closed exteriorily by a diaphragm more or less apparent.

Measurements.—Diameter of orifice. 0.14 mm.; diameter of peristome, 0.18 mm.

Structure.—In spite of its complex appearance, the structure of this species is very simple; it is a *Berenicea*, in which the peristomies of the tubes are separated by mesopores. This *Berenicea* emits

fronds in the *Diastopora* form (double face), having the same character. This is the structure of a large number of Cretaceous fossils classed by Gregory, 1899, in the Petaloporidae and Clausidae. The old genus which corresponds most to our recent specimens is *Cavaria* Hagenow, 1851, where we have also tubes with dorsal gemmation on a basal lamella and separated by irregular mesopores. However, we have cylindrical expansions and not hollow colonies with diaphragms.

As the ovicell is unknown we have adopted the genus of the old zoarial nomenclature to classify this species in order not to create a new term which might have to be eliminated after the discovery of the ovicell.

On our recent specimens, as moreover on many of the fossils, may be noted grouped on the same colony the forms *Berenicea* and *Diastopora*.

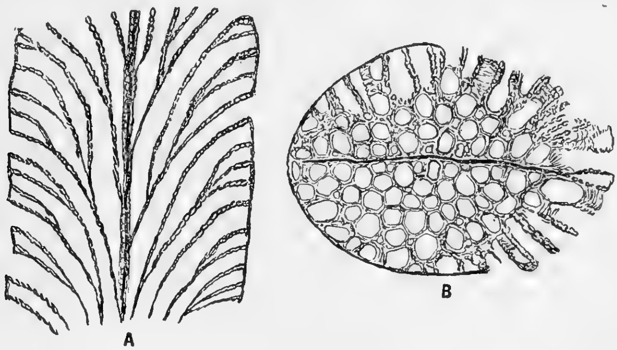


FIGURE 13.—CAVARIA PRAESANS, NEW SPECIES. *A*, LONGITUDINAL SECTION OF A CYLINDRICAL BRANCH, × 16, SHOWING THE TUBES ADJACENT TO THE MEDIAN LAMELLA. *B*, TRANSVERSE SECTION, × 16, EXHIBITING THE CYLINDRICAL TUBES AND THE MEDIAN LAMELLA. THE SMALL PORES ADJACENT TO THE LAMELLAE ARE TUBES WHILE THE MINUTE DISSEMINATED PORES ARE MESOPORES

The classification based on the zoarial form is perfectly useless, as in the Cheilostomata.

Affinities.—Exteriorily this species resembles *Tretocycloecia pelliculata* Waters, 1879, in the presence of closed mesopores between the peristomes. They differ in their internal structure. In Waters's species the gemmation is peripheral and the mesopores are subparietal, as shown in the sections of Waters, 1879, and Canu and Bassler, 1920. Moreover, under the name of *Heteropora pelliculata* several species have been confused. The exact determination of species with mesopores can not be made without sections.

Biology.—Our specimens, having been separated from their substratum, prove that only they came from the depths indicated by their surrounding. Moreover, they were dead. The zoarial surface is wrinkled transversely. These wrinkles overlap on the closures of

the mesopores. There is, then, a kind of exterior calcification rather difficult to understand on incomplete specimens.

Occurrence.—Galapagos Islands, D. 2813 and D. 2815.

Holotype.—Cat. No. 8533 U.S.N.M.

HETEROPORA, species

Plate 9, Figures 4–6

Our photograph shows two small incomplete colonies. The peristome is hardly salient and measures 0.10 mm. in diameter; it bears a small distal visor (galea) directed toward the base of the colony, as in certain *Lichenoporas;* its orifice measures 0.08 mm. in diameter. The peristomes are arranged in quincunx distant from each other 0.30 mm. and separated by smaller irregular polygonal pores.

The colony is bordered inferiorily by a smooth basal lamella little enlarged, which appears to be the true zoarial margin.

Without ovicell or sections it was impossible for us to give an exact idea of the structure of this species. It recalls certain *Multicrescis* of the Cretaceous, and it would be interesting to make a detailed study of it.

Occurrence.—Galapagos Islands, D. 2813.

Cat. No. 8534, U.S.N.M.

EXPLANATION OF PLATES

PLATE 1

FIGS. 1, 2. *Aplousina filum* Jullien 1903 (p. 5).

1. Portion of the incrusting zoarium, × 20, showing the small zooecia with ectocyst and the endozooecial ovicell.
2. Surface of zoarium, × 20, with large zooecia covered by the ectocyst. The opercular valve is wide but very short.

Albatross Station D. 2813.

3–7. *Membrendoecium claustracrassum*, new species (p. 7).

3. The incrusting zoarium, × 20, with little calcified zooecia in immediate contact with the substratum.
4. Zooecia with ectocyst, × 20, showing the endozooecial structure of the ovicells. The zooecium without ectocyst is regenerated.
5. Ancestrular region, × 20.
6. Ectocysted zooecia, × 20, showing the large operculum of the ovicelled zooecia and the small opercular valve of the ordinary zooecia.
7. Calcified zooecia, × 20, of the external lamella of an incrusting multilamellar colony.

Albatross Station D. 2813.

8. *Callopora verrucosa*, new species (p. 9).

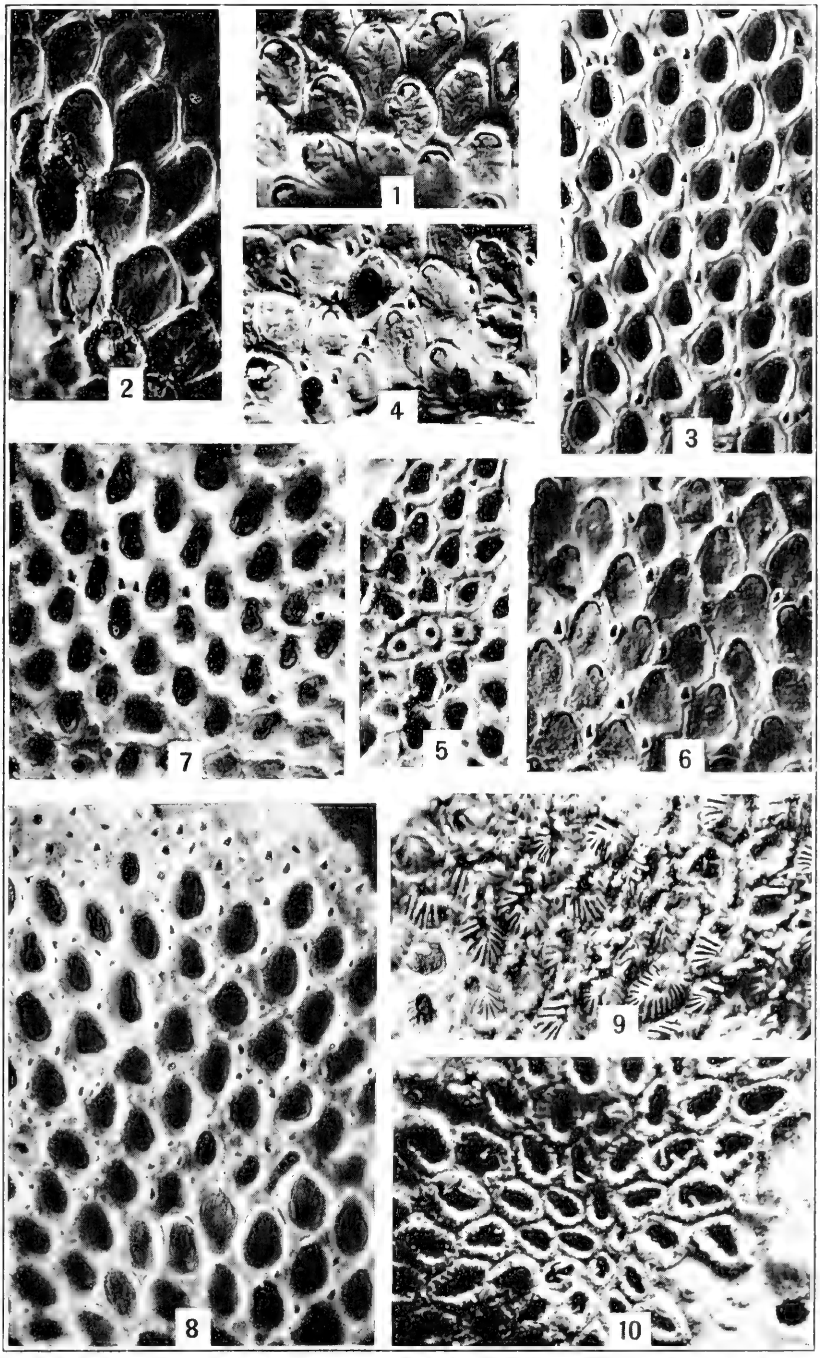
Portion of the incrusting colony, × 20. The normal zooecia are at the base. The marginal zooecia have zooeciules on their mural rim. The marginal zooeciules have stopped the growth of the colony.

Albatross Station D. 2813.

9, 10. *Cauloramphus brunea*, new species (p. 10).

9. Incrusting specimen, × 20, preserving the spines which are brown in the original. The pedunculated avicularia are white.
10. Ancestrular portion of a colony which has lost its spines, × 20.

Albatross Station D. 2815.



BRYOZOA OF GALAPAGOS ISLANDS

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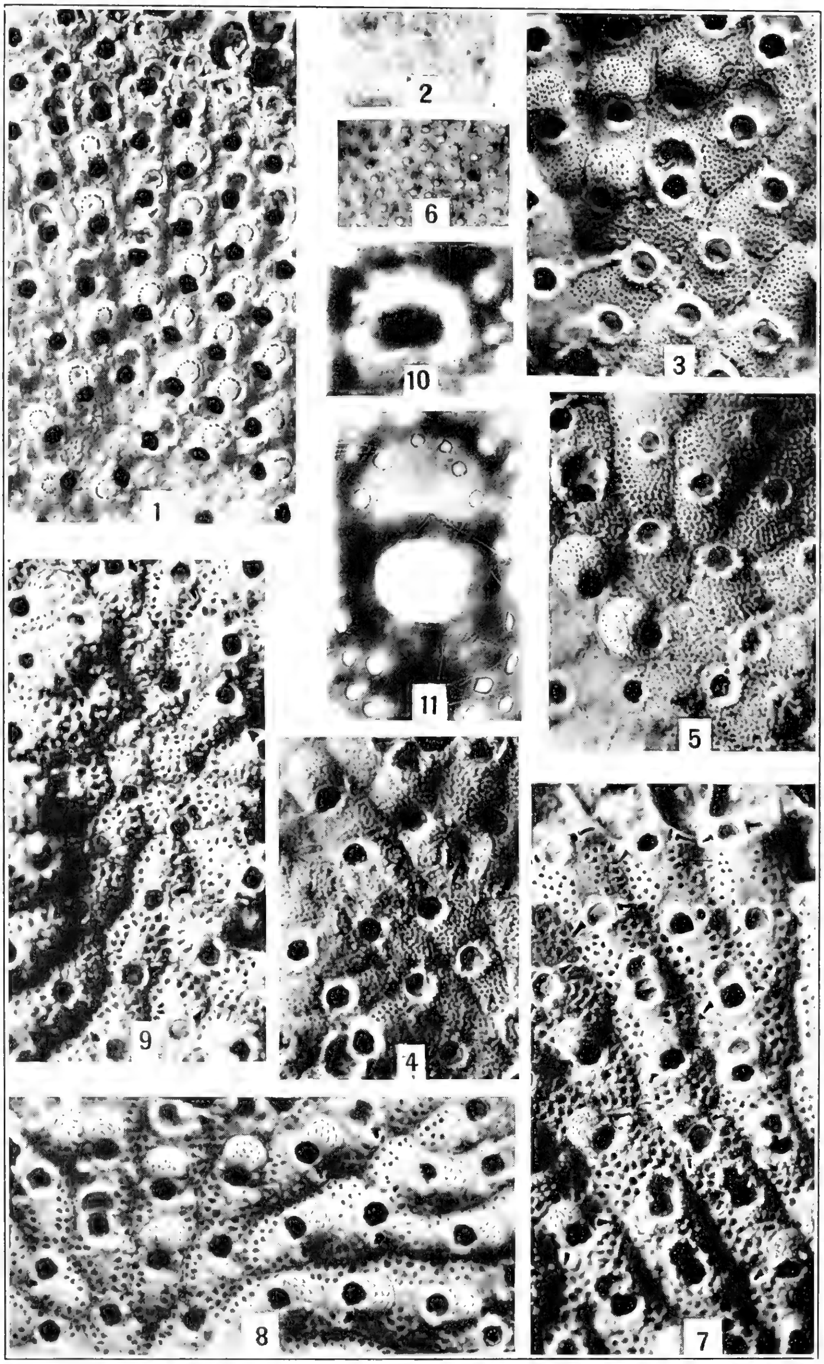

BRYOZOA OF GALAPAGOS ISLANDS

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Plate 2

Figs. 1, 2. *Schizopodrella* (*Stephanosella*) *biaperta* Michelin, 1842 (p. 16).

1. Portion of an incrusting ovicelled colony, × 20.
2. Structure of the frontal, × 85, showing the small tremopores.

Albatross Station D. 2813.

3–6. *Dakaria sertata*, new species (p. 17).

3. Incrusting zoarium, × 20, showing the frontal of the zooecia and the ovicell which have the same structure.
4. Irregular zooecia in the ancestrular region, × 20.
5. The zooecia are poorly oriented. The peristome is thick and festooned proximally; × 20.
6. Structure of the frontal with small tremopores, × 85.

Albatross Station D. 2813, and D. 2815.

7–11. *Hippomenella parvicapitata*, new species (p. 19).

7. Incrusting specimen, × 20, showing the broad cells some of which have no pleurocyst. No dietellae.
8. An example, × 20, in which the narrow zooecia have only a single avicularium.
9. Specimen, × 20, showing the ancestrula. The irregularity of the substratum has determined the development and an abnormal direction of the cells.
10. View by transparency of the embryo in the ovicell, × 85.
11. A cell viewed by transparency showing the frontal structure, the ovicell, areolar pores and pleurocyst.

Albatross Station D. 2813.

Plate 3

Figs. 1, 2. *Microporella gibbosula*, new species (p. 20).

1. Incrusting specimen, × 20, showing the micrometric variations from the ancestrula to the marginal zooecia.
2. Ovicelled specimen much calcified, × 20. The form of the avicularia is altered by the intensity of calcification.

Albatross Station D. 2813.

3–5. *Microporella tractabilis*, new species (p. 22).

3. Incrusting zoarium with ovicelled zooecia, × 20. The ovicells have the same structure as the frontal.
4. An example with setiform avicularian mandibles, × 20. The point of the latter touches the pivot of the avicularium of the adjacent superior zooecium.
5. Structure of the frontal, shown by transparency, × 85. The ascopore is large and triangular.

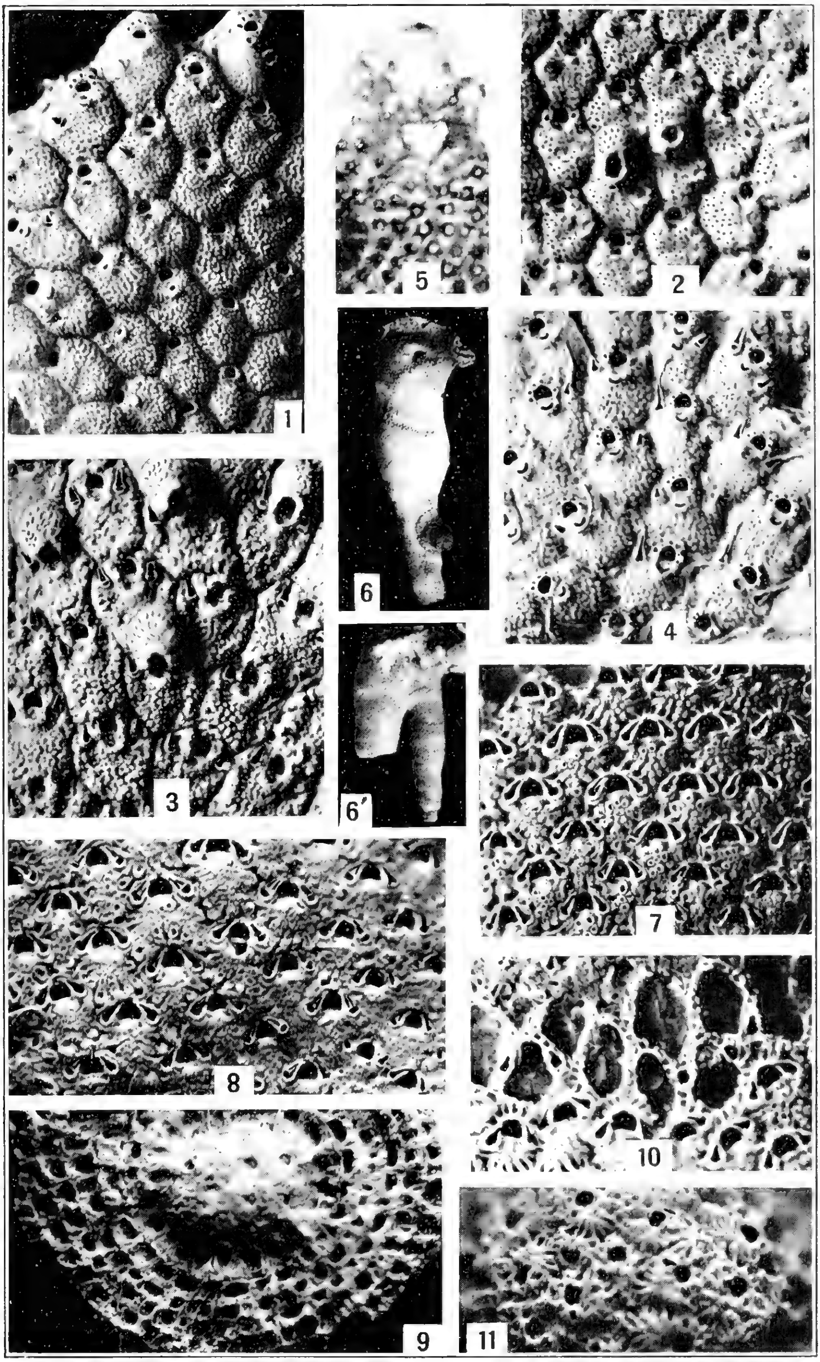
Albatross Station D. 2815.

6–11. *Enantiosula manica*, new species (p.23).

6,6.[1] Two colonies, natural size, showing their real position.

7. Surface, × 20, showing young zooecia with tubular tremopores.
8. Fragment of a lamella, × 20, on which the tremocyst is much calcified and the frontal tubules are adjacent.
9. Portion of a transverse section of a colony, × 10, showing the superposed concentric lamellae.
10. Margin of a lamella, × 20, illustrating the parietal dietellae formed before the frontal and the aperture. The avicularia are visible among the dietellae.
11. End of a branch, × 20. The cells are much calcified and unadorned. The tremopores are closed by costules.

Albatross Station D. 2815.



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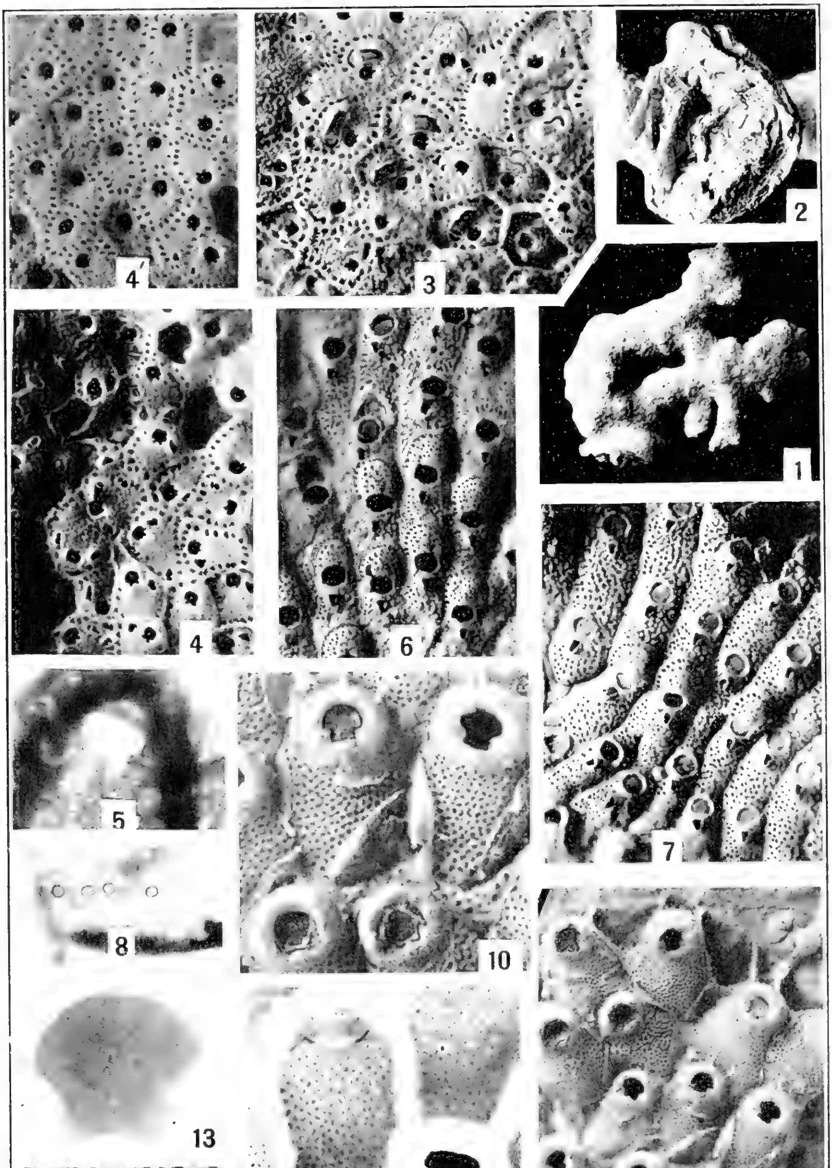

BRYOZOA OF GALAPAGOS ISLANDS

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PLATE 4

FIGS. 1–5. *Smittina trispinosa* Johnston, 1838 variety (p. 27).

1, 2. Zoarium, natural size and base of same, × 2.

3. Another example, × 20 with ovicelled zooecia, and also zooecia with small avicularia as well as those with large avicularia, ornamented with a mandible.

4. Zoarium, × 20, in which the zooecia do not have large avicularia. The small avicularia are always elliptical; sometimes some of them are triangular.

4.[1] Zooecia, × 20, without avicularia or only a single one present.

5. View by transparency, × 85, showing the arrangement of the cardelles and of the lyrule in the aperture.

Albatross Station D. 2813.

6–8. *Codonella granulata*, new species (p. 29).

6. Surface of the incrusting specimen with regular zooecia, × 20.

7. Zoarium with irregular zooecia, × 20. The frontal granulations are quite visible between the tremopores.

8. Lateral wall of the zooecium showing the four uniporous septulae, × 85.

Albatross Station D. 2815.

9–13. *Pachycleithonia nigra*, new species (p. 25).

9, 10. Surface of the incrusting zoarium, × 10 and several zooecia, × 20. The ectocyst persists on some of the zooecia as a torn film.

11. Interior, × 20, showing the operculum in place in one zooecium and the condyles and lateral canals under the condyles in others.

12. Structure of the frontal, × 85.

13. Operculum, 85.

Albatross Station D. 2815.

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Plate 5

Figs. 1–4. *Diplonotos costulatum*, new species (p. 30).

1, 2. Fragment of zoarium, natural size, and the first lateral face of the reticulated colony, × 20, bearing vibices and avicularia.

3. Second lateral face of the same colony × 20, showing the same features.

4. Cellular side, × 20. It is uniserial and the zooecial openings are arranged on the edge of the branches in the fenestrae.

Albatross Station D. 2813.

5. *Crepidacantha poissonii* Audouin, 1826 (p. 33).

Portion of the incrusting zoarium, × 20.

Hawaiian Islands, Albatross Station D. 3813.

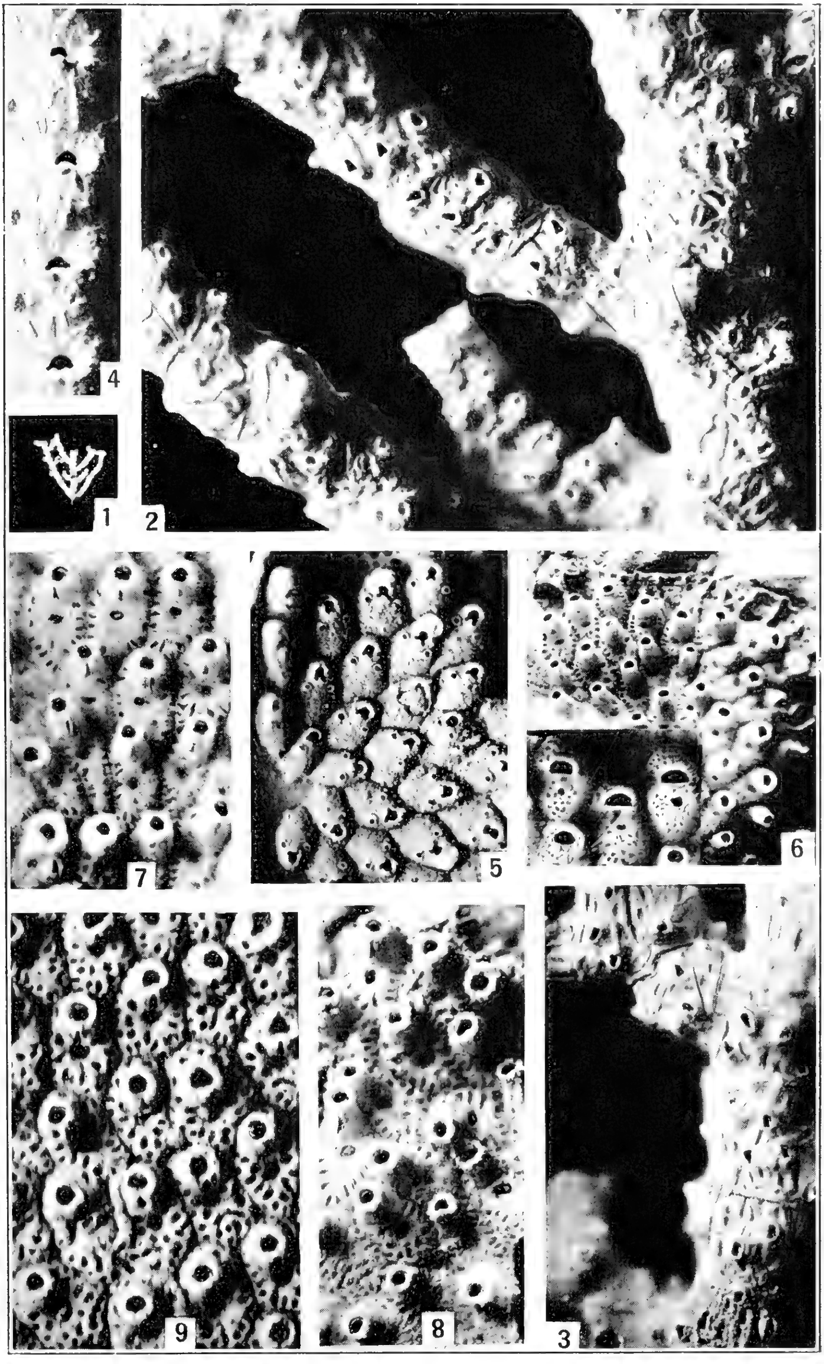
6–9. *Adeona tubulifera*, new species (page 34).

6. Portion of the incrusting zoarium, × 10, and a few zooecia of the same, × 20, showing gonoecia.

7, 8. Portions of a colony × 20 with very tubular zooecia.

9. Much calcified colony, × 20. The peristomes are shorter and much thickened.

Albatross Station D. 2815 and D. 2813.



BRYOZOA OF GALAPAGOS ISLANDS

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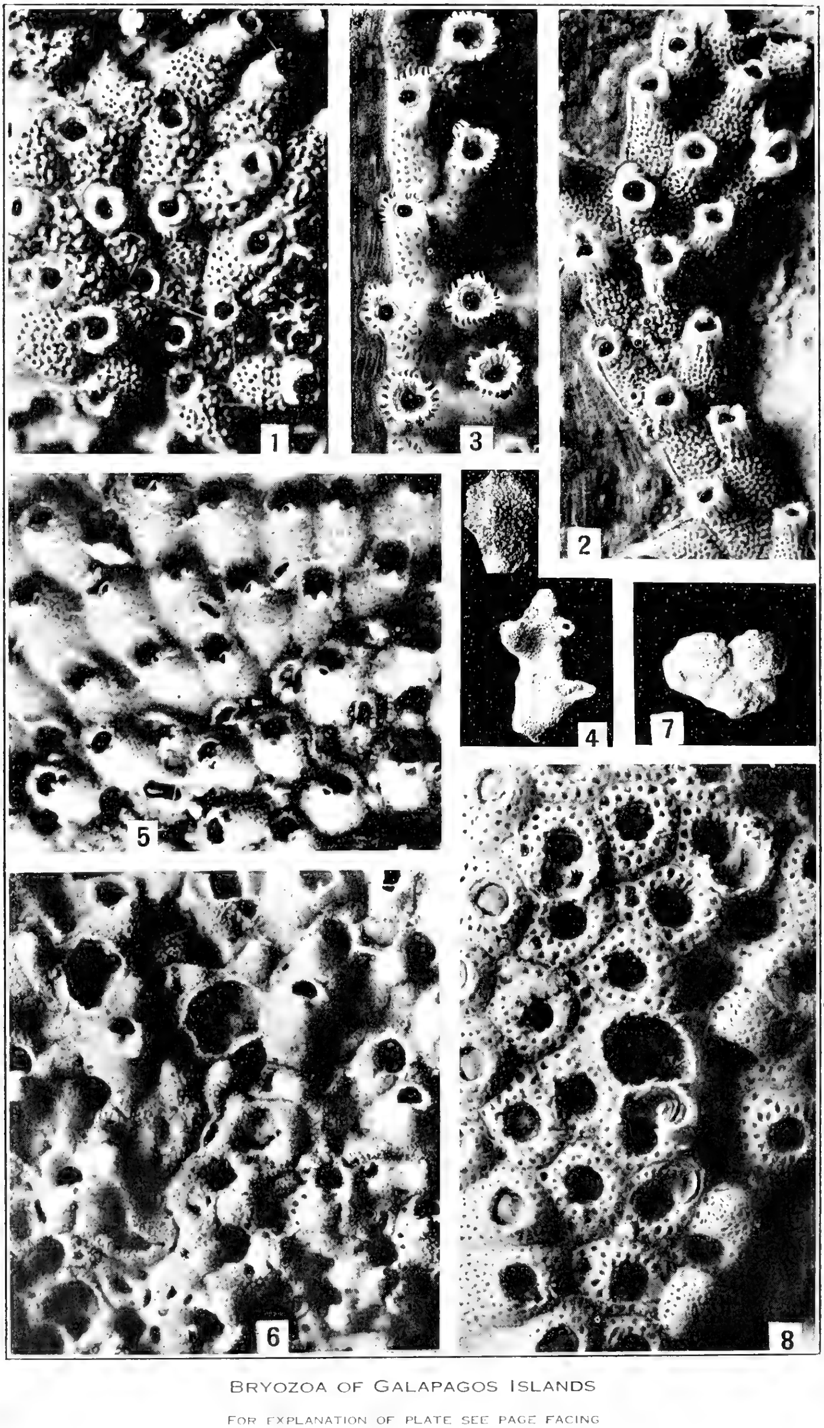

BRYOZOA OF GALAPAGOS ISLANDS

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PLATE 6

FIG. 1. *Lagenipora verrucosa*, new species (p. 35).
Incrusting ovicelled specimen × 20.
Albatross Station D. 2813.

2, 3. *Lagenipora marginata*, new species (p. 36).
2. Incrusting bi-triserial specimen, × 20, The superior cells are operculated.
3. An example, × 20, with laciniated and expanded peristomes of zooecia with long peristomie.
Albatross Station D. 2813.

4–6. *Holoporella quadrispinosa*, new species (p. 37).
4. Two colonies, natural size.
5. Oriented cells of an incrusting colony, × 20. There are small frontal avicularia.
6. Cumulate zooecia of a colony, × 20. The small frontal avicularia are buried in the thickness of the frontal.
Albatross Station D. 2813 and D. 2815.

7–8. *Holoporella porosa*, new species (p. 39).
7. Two colonies developed on the same nullipore, natural size.
8. Portion of a colony × 20, showing the ovicells and some operculated zooecia.
Albatross Station D. 2815.

Plate 7

Fig. 1. *Holoporella hexagonalis*, new species. (p. 38).

1. Surface of the colony, × 20. Some zooecia are operculated.

Albatross Station D. 2813.

2, 3. *Holoporella tridenticulata* Busk, 1881 (p. 39).

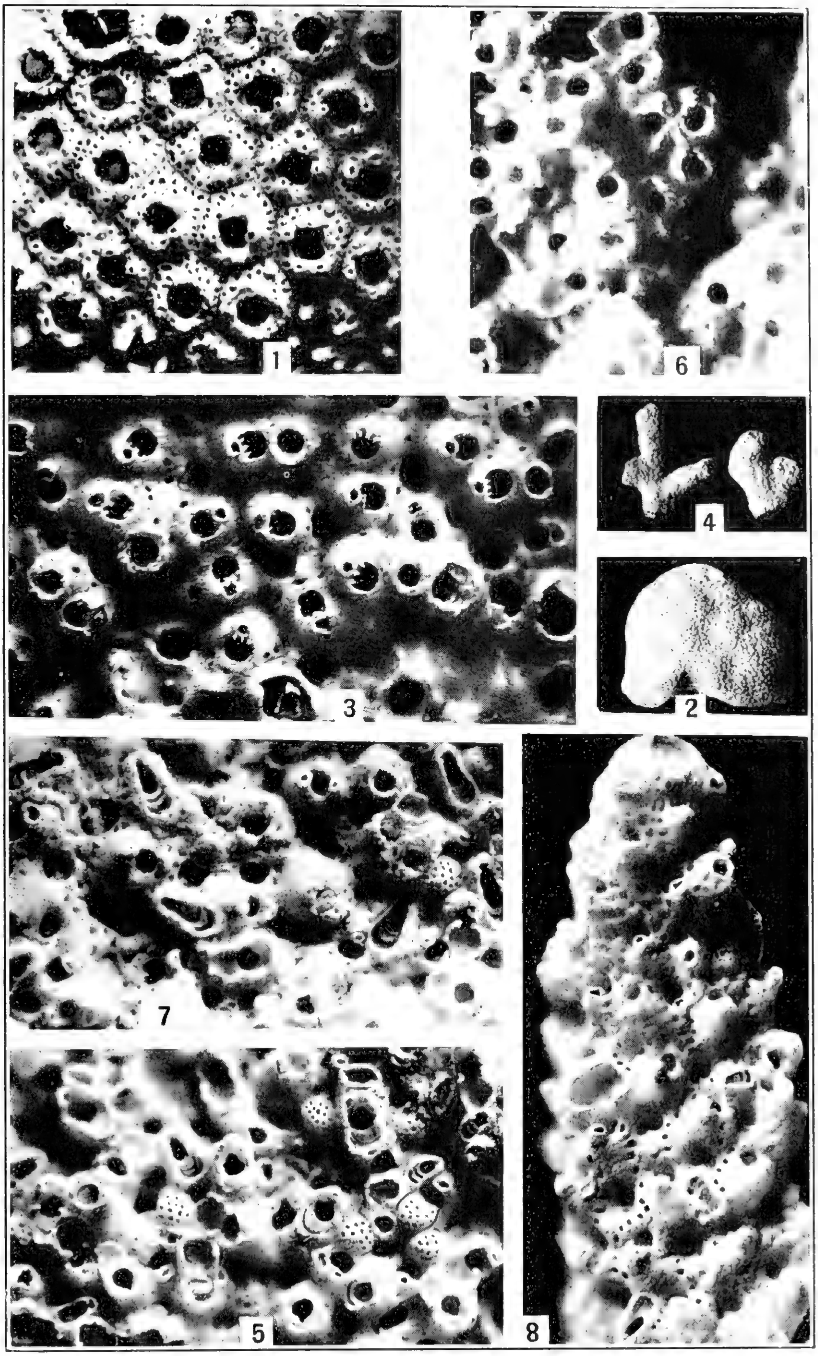
2. The massive colony, natural size.
3. Surface of a large massive colony, × 20, bearing cylindrical, salient tubes.

Albatross Station D. 2815.

4–8. *Osthimosia anatina*, new species (p. 42).

4. Fragments of the ramose zoarium, natural size.
5. Ovicelled portion of a ramose colony, × 20.
6. Portion of a ramose colony, × 20, where the areolar pores are little visible and the ovicells are broken.
7. Surface of a colony, × 20, with large interzooecial avicularia of duck bill shape.
8. Young zooecia, × 20, at the extremity of a branch.

Albatross Station D. 2813 and D. 2815.



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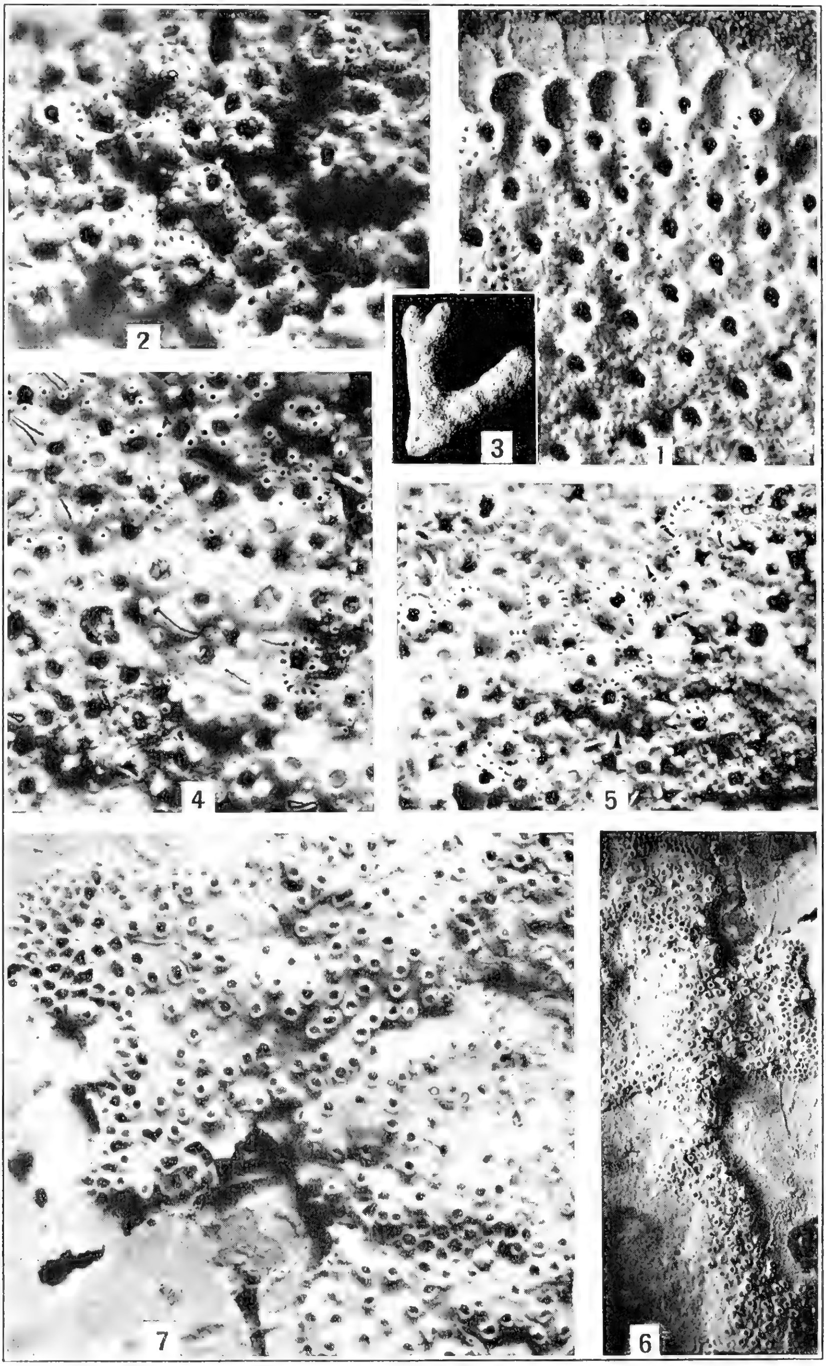

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Plate 8

Figs. 1, 2. *Hippoporidra granulosa*, new species (p. 43).

1. Portion of an encrusting colony with oriented zooecia, × 20.
2. Another part of the same zoarium, × 20, with erect and poorly oriented zooecia.

Albatross Station D. 2813.

3–5. *Hippotrema spiculifera*, new species (p. 43).

3. The ramose zoarium, natural size.
4. Portion of a free colony, × 20, showing the large interzooecial avicularia and the frontal spicules.
5. Zoarial surface, × 20, showing the spicules placed on the frontal of the cells.

Albatross Station D. 2813.

6, 7. *Microecia tubiabortiva*, new species (p. 48).

6. An entire colony, × 4, showing the primitive *Berenicea* emitting various lobes.
7. Portion of the same colony, × 12, showing the ovicell and the spaces with aborted tubes.

Albatross Station D. 2813.

Plate 9

Figs. 1–3. *Chaperia condylata*, new species (p. 44).

1. The incrusting zoarium, × 10.
2. Portion of the same surface, × 20.
3. Zooecia, × 20, preserving the six, large, simple, distal spines.

Albatross Station D. 2815.

4–6. *Heteropora*, species (p. 60).

Two zoaria natural size and, × 12.

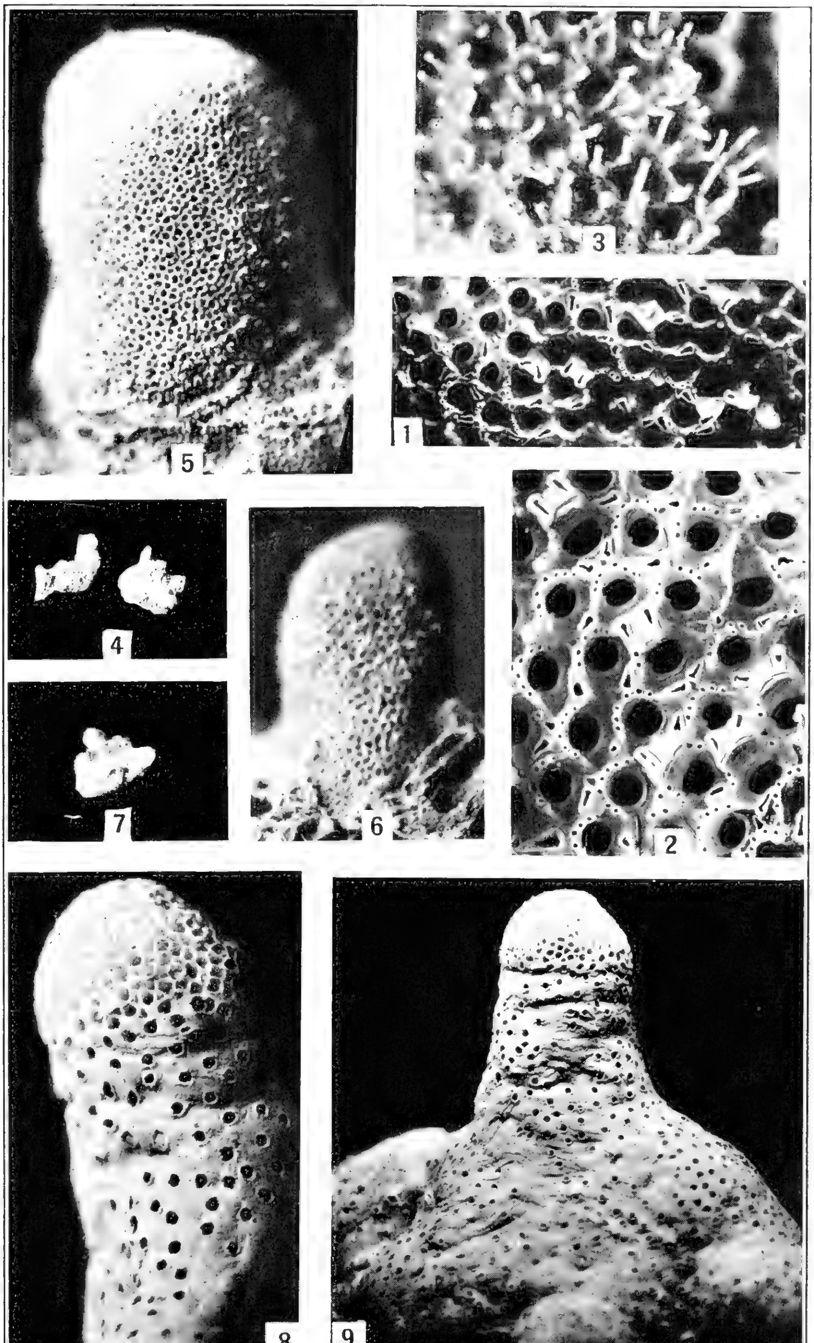
Albatross Station D. 2813.

7–9. *Cavaria praesens*, new species (p. 58).

7. Zoarium natural size.
8. The bereniceoid colony, × 6, emitting cylindrical branches.

The mesopores are biserial under an epitheca.

Albatross Station D. 2813.



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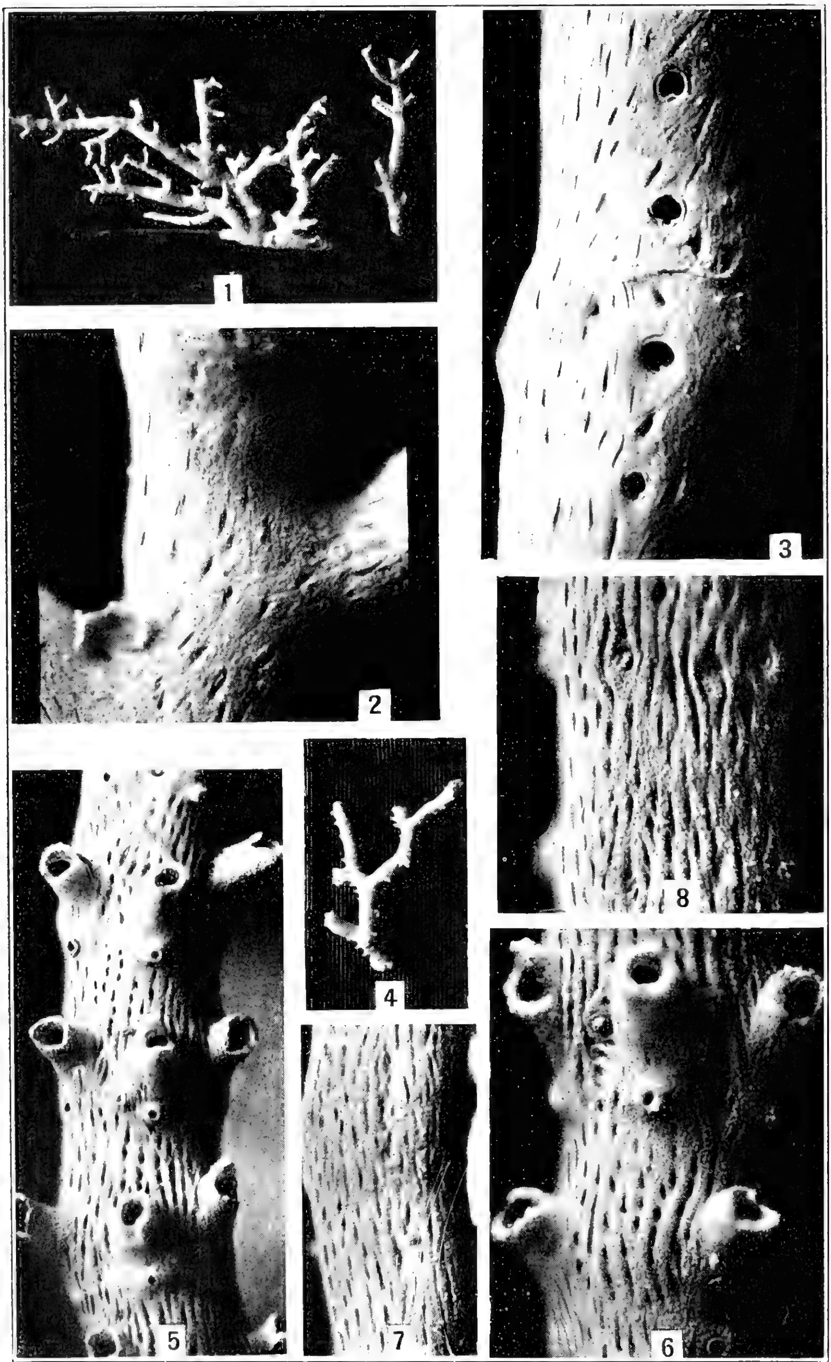

BRYOZOA OF GALAPAGOS ISLANDS

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PLATE 10

FIGS. 1–3. *Diplonotos striatum*, new species (p. 31).

1. An entire colony and a fragment, natural size. The branches show noncellular faces for the apertures are arranged laterally.
2. Noncellular surface, $\times$ 20, with sulci of little depth.
3. Lateral cellular side of branch, $\times$ 20, in which the enlarged portions bear salient transverse vibices.

Albatross Station D. 3408.

4–8. *Semihaswellia sulcosa*, new species (p. 15).

4. Colony, natural size.

5, 6. Frontal cellular side, $\times$ 12 and a portion, $\times$ 20, showing the longitudinal sulci.

7, 8. Dorsal side, $\times$ 12 and $\times$ 20, with longitudinal sulci and very small vacuoles.

Albatross Station D. 3408.

Plate 11

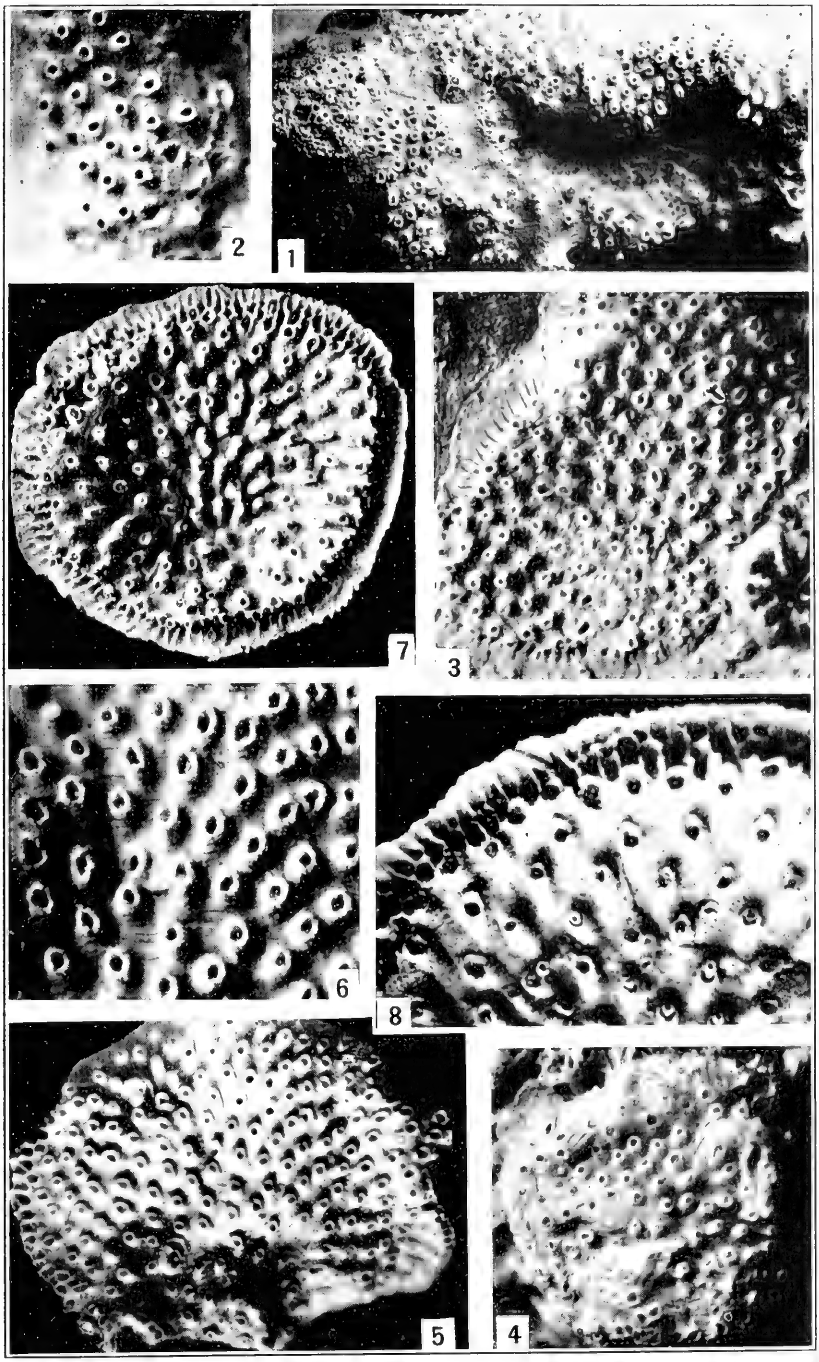
Figs. 1, 2. *Proboscina lamellifera,* new species (p. 46).
The incrusting zoarium, × 6 and a portion × 12.
Albatross Station D. 2813.

3–6. *Diaperoecia striatula,* new species (p. 49).
3. A colony incrusting in concentric wrinkles with a wide basal lamella and an ovicell.
4. An example, × 12, with three ovicells.
5. A free colony, × 12.
6. Portion of fig. 5, × 25, to show the concentric striae.

Albatross Station D. 2813.

7, 8. *Plagioecia lactea* Calvet, 1903, var (p. 48).
7. A complete free colony, × 12, with marginal ovicell.
8. Portion of the same, × 25, to show the tubes closed by a diaphragm with tubule.

Albatross Station D. 2813.



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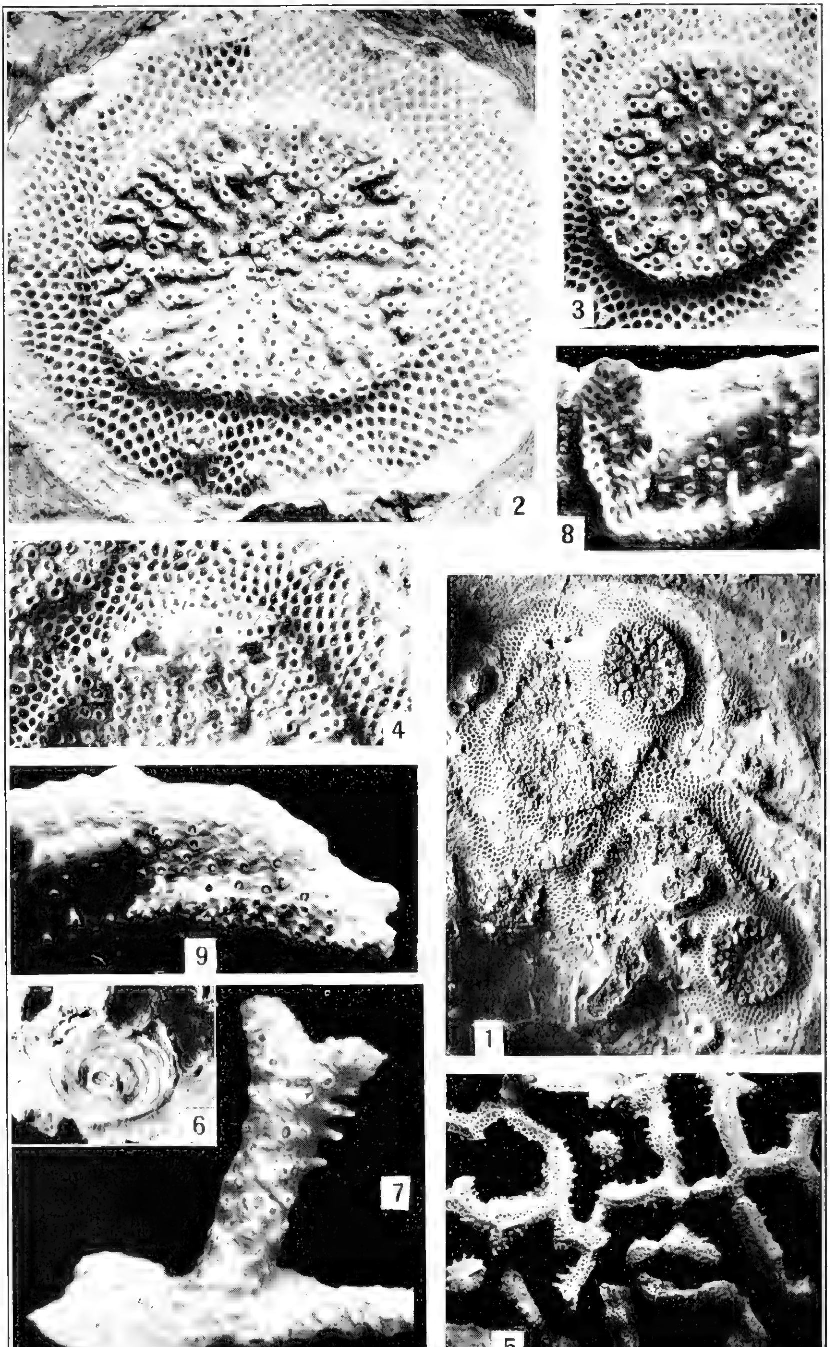

BRYOZOA OF GALAPAGOS ISLANDS

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Plate 12

Figs. 1–4. *Diaperoecia? subpapyracea*, new species (p. 50).

1. Superposed colonies, × 4, arising from many successive larvae.
2. A large isolated colony, × 12, showing the arrangement of the tubes in radial rows and the large smooth basal lamella.
3. A small isolated colony, × 12, showing the irregular arrangement of the peristomes.
4. Portion of an incrusting colony, × 12, illustrating the marginal ovicell.

Albatross Station D. 2813.

5–9. *Diaperoecia meandrina*, new species (p. 51).

5. Superior face, × 4, showing the zoarial reticulations, the basal lamella, and the great saliency of the superior tubes.
6. Base of the same zoarium, × 4. The primitive *Berenicea* is visible, as is also the point of attachment.
7. Dorsal of a young branch, × 12. It is formed from the principal branch by a bifurcation of the basal lamella in which the two parts are attached back to back.
8. Lateral face of an ovicelled branch, × 12, showing the insertion of a secondary branch.
9. Lateral view of a young ovicelled branch, × 12, illustrating the growth of the basal lamella by the addition of new recurved tubes. Sometimes the tubes are closed by a diaphragm with a tubule.

Albatross Station D. 2815.

PLATE 13

FIGS. 1–10. *Tubulipora liliacea* Harmer, 1898 (p. 54).

1. Incrusting colony, × 12, commencing in the linear form.
2. Incrusting specimen, × 12, showing the small protoecium, the ovicell, and the oeciostome.
3. The initial linear portion, × 12, of example shown in Figure 1.

4, 5. Incrusting flabellate zoarium, × 4, and × 12, the latter showing the ovicell.

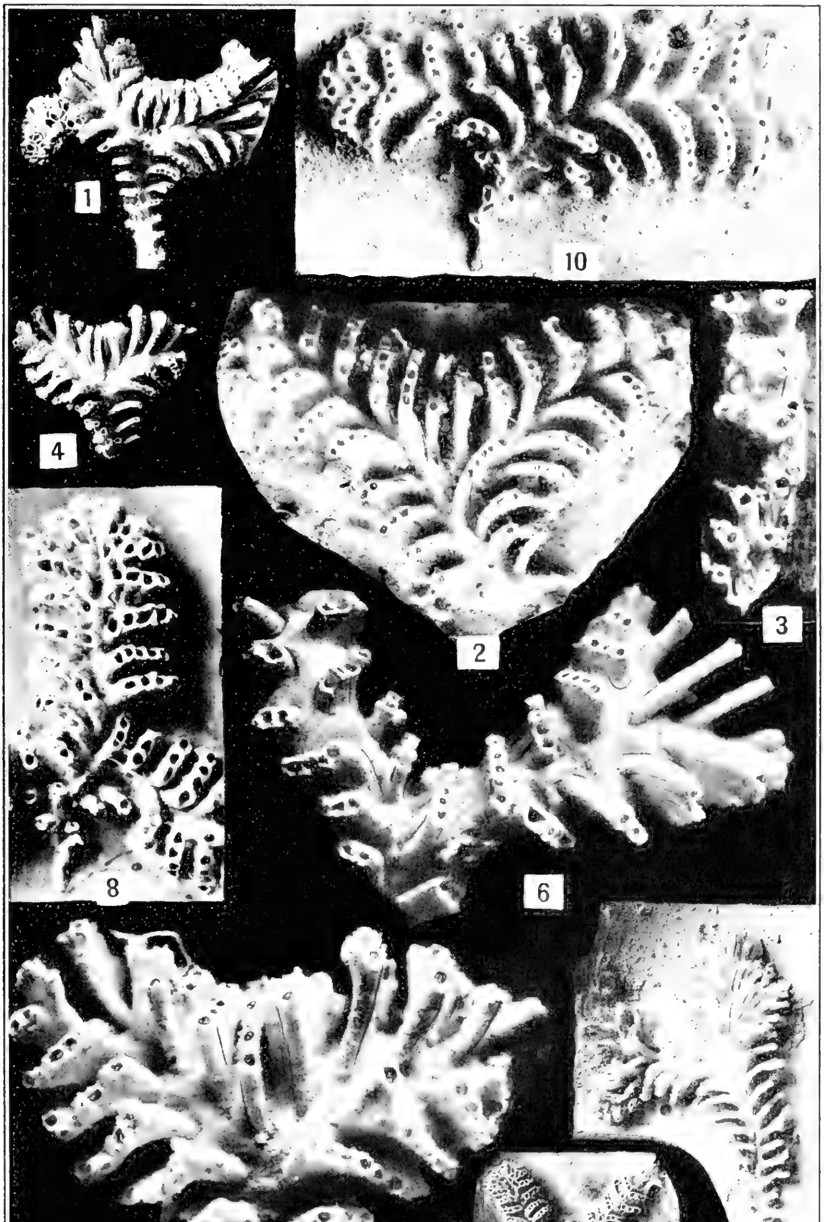
6. Bifurcated ovicelled specimen with linear branches, × 12.
   Banc de Rokall, Spain (Atlantic).

7, 8. Incrusting specimen, × 4 and a portion × 12, showing the very small protoecium.
   Atlantic, LaCroisic, Manche.

9. Another example with small protoecium, × 4.
   English Channel, Etretat, France.

10. Incrusting colony, × 12. The ovicell and the oeciostome are not entirely formed.

Albatross Station D. 2815.



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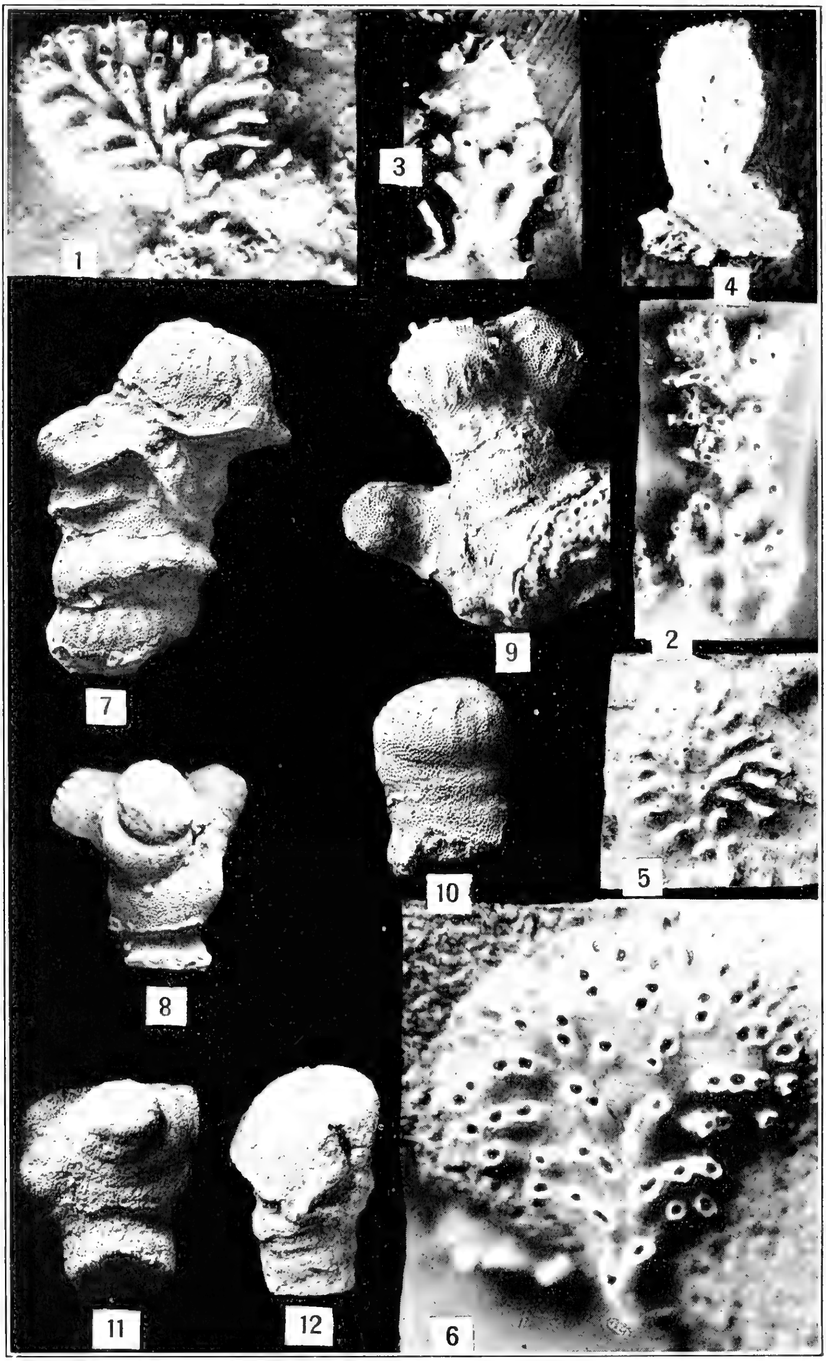

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PLATE 14

FIGS. 1–4. *Tubulipora tubulifera* Lamouroux, 1821 (p. 53).

1. Flabellate specimen growing on an alga, × 12.
2. Linear specimen, × 12, with interrupted fascicles, incrusting an alga.
3. Linear ovicelled specimen, × 12, attached to an alga.
4. Dorsal face of a specimen, × 12, showing the cylindrical tubes.

Porto d'Anzio, Italy.

5. *Tubulipora*, species (p. 54).

Small incrusting, ovicelled specimen with the oeciostome visible, × 12.

Albatross Station D. 2813.

6. *Tubulipora*, species (p. 52).

Small ovicelled specimen, × 25. The oeciostome is recumbent and adjacent to a tube.

Albatross Station D. 2815.

7–12. *Defrancia stellata* Reuss, 1847 (p. 57).

7. An example, × 4, with superposed colonies.

Sahelian, Oran (Algeria).

8. An example, × 12.

Lower Miocene (Burdigalian), El Amran, Algeria.

9. Specimen attached to a Cellepore.

Albatross Station D. 2815.

10–12. Specimens from the Helvetian (Miocene) of France.

INDEX

U. S. GOVERNMENT PRINTING OFFICE: 1929

THE MIDDLE DEVONIAN TRAVERSE GROUP OF ROCKS IN MICHIGAN, A SUMMARY OF EXISTING KNOWLEDGE

By Erwin R. Pohl

Of the Department of Geology, Vanderbilt University, Nashville, Tenn.

INTRODUCTION

It has become more and more obvious with the progress of laboratory and field studies on the faunas and stratigraphy of the Michigan Traverse group of Middle Devonian age that no exact correlation between deposits in the eastern and western parts of the State can be established. This conclusion will serve as the focus of major inferential consideration for the discussion that follows, and while the greater portion of this paper will be devoted to the establishment of the stratigraphic sequence of the Traverse Bay area, the truth of the deduction will appear through comparison of this section with the more completely developed group bordering Lake Huron.

Newly introduced terms must necessarily be provisional, for the study of this problem in its true light is still in its beginning. Such names are here used merely as a means of clarifying a visualization of the stratigraphic conditions contemporaneous with the deposition.

From the standpoint of pure science the most engrossing phase of geological investigation is to the author the derivation of faunas. Marine faunas, so typically encountered in the Traverse, require rational consideration. It appears trite to remark that an association of shallow water invertebrate species, however long extinct, reacted no more peculiarly to their environment than their living representatives. It was an odd individual, not to say species or assemblage, that would walk on dry land or fly through the air from one basin of deposition to another. And yet, were we to allow the gross differences in so-called conspecific forms and associations considered as being present contemporaneously in one and the same depositional basin to be disregarded—as they so flagrantly have been and still are—we must accept some such supernatural attribute on the part of formerly existing organisms. The pathway of encroachment by the Traverse stages into Michigan will be studied by means of species having characteristics limited by physical possibility.

Location and distribution.—The known areal occurrence of Traverse rocks proper is unequally threefold. By good fortune these three areas of outcrop combine toward a solution of two of the greatest stratigraphic problems—sequence and correlation. No two of these occurrences afford the necessary ties without the third, and they are all therefore of equal importance in any consideration of the Traverse problem.

The area of greatest surface development of these rocks occurs within the boundaries of the five northernmost counties of the Lower Peninsula of Michigan—Charlevoix, Emmet, Cheboygan, Presque Isle, and Alpena—forming thus the outer edge of one of the structural "saucers" centering near Saginaw Bay. That this broad structure is of post-Paleozoic origin will be shown under a later heading. Numerous cement and alkali enterprises have resulted in the excavation along the outcrop of some of the largest lime quarries in the United States, which in conjunction with the shore exposures bordering Lakes Michigan and Huron give the line of sections a southwardly crescentic trend. Northward of this narrow line the surficial distribution is abruptly broken by a thick covering of the ground moraine, and to the southward the limestones of the Traverse disappear beneath the succeeding black shales of Waverlian and possibly Devonian age.

The southernmost outcrop of undoubted Traverse beds is found in the northwestern portion of Lucas County, Ohio. The details of the sections obtained here and their peculiar significance will be discussed with those of the third occurrence of Traverse rocks, a portion of the Thunder Bay series on and near the east shore of Lake Huron in Lambton, Huron, and Middlesex counties, Ontario.

Nomenclature and former conceptions.—It is needless in a paper of this character to recount the historical development of geological knowledge of the Traverse beds of Michigan, especially in view of the fact that the present investigation has shown remarkable incongruities in all phases of the study. These are in most cases entirely excusable, since they are partly due to formerly prevalent misconceptions and misunderstandings of conditions of deposition, partly to the incompleteness of stratigraphic preservation, and partly to a lack of necessary details, especially in the matter of authentic well records.

The solutions of the problems here presented have been accomplished entirely independently under the auspices of the United States National Museum with the assistance of Mr. G. O. Raasch of the Milwaukee Public Museum, and there has been a purposeful disregard of all previous work, published or otherwise, with the exception of the results of the 1926 Michigan Survey field party, in cooperation with the United States Geological Survey, represented

by Dr. E. O. Ulrich, who has very generously allowed full access to all his field notes and collections. Since that time I have been favored with the complete confidence of the officers of the Geological Survey of Michigan, who have made available to me all the information at their disposal.

Since early in the nineteenth century accounts of the Devonian rocks of the Southern Peninsula have commanded a prominent place in geologic literature. The earliest local name reference to these beds was made in 1841 by C. C. Douglass,[1] who referred to them in their Lake Michigan occurrences as the "Little Traverse Bay limestones," while those bordering Lake Huron were called the "Thunder Bay limestones." A. C. Lane[2] indirectly grouped all strata between the Dundee and the black shales under the term Traverse, dropping the, according to his conception, useless prefix "Little," and omitting reference to the Thunder Bay. Actual stratigraphic conditions, however, would have been better served by a retention of the original nomenclature.

An attempt to rectify the nomenclature must take into consideration the fact that the two original names applied by Douglass were adequately described according to our more recently accepted nomenclatorial system. As regards the "Thunder Bay limestone," the term has already been properly restricted to the upper third of the Lake Huron section by Grabau.[3] This will be hereinafter referred to as the Thunder Bay stage (faunal delimitation). Douglass's loosely defined locality of outcrop of his "Little Traverse Bay limestone" is now known to exhibit several distinct stratigraphic units, and since he unquestionably applied this term to all beds occurring on the shores of Little Traverse Bay, as is seen in his indefinite geologic section for the region, it is here suggested that the term be dropped. This disposition will further relieve possible confusion were two terms as closely similar as "Little Traverse" and "Traverse" retained, even though they be of different stratigraphic value.

The first use of the abbreviated title "Traverse" was made by Lane.[4] His usage of the term to include all beds lying between the limestones of Onondaga age and the black shales of Upper Devonian and Waverlian deposition is here retained. It is, however, proposed to extend the rank of the term to the position of a group, for as we shall see the area designated in Douglass's and Lane's descriptions represents the development of several distinct faunal and stratigraphic units.

[1] Douglass, C. C. Michigan Senate Document No. 16, 1841.
[2] Lane, A. C. Geol. Surv. Mich., vol. 5, pt. 2, p. 24, 1893.
[3] Grabau, A. W. Mich. Geol. Surv. Ann. Rept. for 1901, p. 192, 1902.
[4] Lane, A. C. Geol. Surv. Mich., vol. 5, pt. 2, p. 24, 1893.

The Bell shales, because of their lithological unity, have been separated as the basal Traverse group formation of the Lake Huron section by Grabau.[5] There is no good reason for the assignment of this widespread lithologic member to a distinct formation, for the contained fauna indicates continuous relationship with the succeeding Long Lake beds which are, incidentally, but slightly more calcareous. Grabau[6] has more recently corrected this detail and assigned the Bell shales their proper place as the basal member of the Presque Isle series[7] which further includes the respectively higher Grand Lake and Long Lake members.

A study of the stratigraphic contacts between the Presque Isle, Alpena,[8] and Thunder Bay series has nowhere been given the slightest attention. Faunal distinction is, however, shown to be sharp between the three series, and it is therefore provisionally proposed to refer to them as stages, in conformity with the terminology of similarly unestablished but probable formations.

TRAVERSE BAY SEQUENCE

"Complex" becomes but a mild term when applied to actual stratigraphic, biologic, and structural conditions within the Traverse. For a clear understanding of the subject as a whole it must therefore be separated into its component parts and each discussed individually with evidences for the present interpretation, finally by summary comparison drawing similarities and variances between the separately described portions. Stratigraphically, for present purposes, Traverse rocks in Michigan may be studied independently in their eastern and western occurrences, primarily because of the impossibility of direct lithologic or faunal correlation between the two. Each area will be seen to constitute an entity of sequential events in itself. Of the western section we shall speak first.

The development of geologic understanding of the Traverse group has been until recently much hindered by the comparatively unexploited condition of the country in which it occurs and further through the lack of adequate natural outcroppings. The district bordering Lake Huron has outstripped the Traverse Bay region in industrial development, and as an indirect result of the greater exploitation of natural resources there is a fuller understanding of stratigraphic conditions in the eastern portion of the Traverse belt. In the past decade, however, the Traverse Bay district in Charlevoix and Emmet counties has received greater industrial appreciation and the opening of additional quarries in the vicinity of Petoskey has

[5] Grabau, A. W. Mich. Geol. Surv. Ann. Rept. for 1901, p. 191, 1902.
[6] Grabau, A. W. Unpublished manuscript, p. 290, 1915.
[7] Grabau, A. W. Manuscript, pp. 290–308, 1915.
[8] Grabau, A. W. Mich. Geol. Surv. Ann. Rept. for 1901, p. 175, 1902.

greatly facilitated the unraveling of the heretofore much misunderstood sequence of events and the measurement of stratigraphic thicknesses.

Of former interpretations of the geology of the Traverse Bay district the nearest approach to stratigraphic truth was gained by Rominger.[9] The very paucity of material from which this geologist deduced his results attests his close observation and remarkable acumen of mind. It is totally pardonable that his estimate of the thickness of the exposed section was underrated by nearly 120 feet when we remember that he was first to correct far grosser misinterpretations made by previous workers in the same field.

STRATIGRAPHIC UNITS

Three new terms applying to as many distinct faunal and stratigraphic units are here proposed. The defense for the introduction of each will be treated separately. It has been found necessary to separate the exposed section of the Traverse Bay region into a lower, a middle, and an upper division; and, since there is no way of recognizing these divisions in comparable portions of the section in eastern Michigan, to designate them by new geographical names as nearly typical of their individual development as is possible. In ascending order these divisions are—the Gravel Point stage, the Charlevoix stage,[10] and the Petoskey formation.[11]

Detailed sections.—In the Traverse Bay district field locality numbers have been applied to the many isolated outcrops of Traverse rocks. These have been used in conformity with those employed by the 1926 Michigan Survey field party, although the original number of observed and studied sections has been doubled in the present investigation. The majority of localities investigated are of secondary importance only, since they reveal in duplicate more limited representations of elsewhere more favorably developed sections. A list of the "key localities" follows:

Locations of sections from which the complete sequence of Traverse beds in the Traverse Bay district may be derived.

Locality 7c.—Low bluff on shore of Grand Traverse Bay, 1 to 2 miles northwest of Norwood, about a mile, in secs. 22 and 28, T. 33 N., R. 9 W., Charlevoix County, Mich.

Locality 8.—Ledges and bluffs on shore of Lake Michigan, 1½ miles west of Charlevoix, in secs. 28 and 29, T. 34 N., R. 8 W., Charlevoix County, Mich.

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[9] Rominger, C. Mich. Geol. Surv., vol. 3, pt. 1, pp. 53–63, 1876.

[10] The physical evidence for the separation of the Gravel Point and the Charlevoix beds has not been studied with sufficient intensity to warrant the establishment of the formational rank of these faunally distinct stages at the present time.

[11] This name was first applied by Grabau, (Rept. Geol. Surv. Mich., p. 201, 1901), to beds largely equivalent to the formation herein proposed, but without proper delimitation. Since the term is particularly applicable it has been here adapted to the usage proposed.

Locality 8.—Ledges and bluffs on shore of Lake Michigan, 1½ miles west of Charlevoix, in secs. 28 and 29, T. 34 N., R. 8 W., Charlevoix County, Mich.

Locality 8a.—Shore of Lake Michigan from locality 8 to about 1 mile south, Charlevoix County, Mich.

Locality 13.—Main Curtiss quarry, two smaller quarries, and shore bluffs to the west. "Bay Shore quarries." SW. ¼ sec. 6, T. 34 N., R. 6 W., Emmet County, Mich.

Locality 14.—Petoskey Portland Cement Co. quarry, 1¼ miles west of Petoskey city line, SW. ¼ sec. 2, T. 34 N., R. 6 W., Emmet County, Mich.

Locality 14c.—Abandoned quarry one-half mile west of the west end of the Petoskey Portland Cement Co. quarry, (Locality 14*a*), and about one-eighth mile south of Little Traverse Bay. NW. ¼ of the NE. ¼ sec. 9, T. 34 N., R. 6 W., Emmet County, Mich.

Locality 14e.—Abandoned "Bell" quarry, extreme NE. ¼ sec. 8, T. 34 N., R. 6 W., and ledges on shore to west, Emmet County, Mich.

Locality 18.—Northern Lime Co. quarry, bordering Little Traverse Bay near east end of Petoskey, NE. ¼ sec. 32, T. 35 N., R. 5 W., Emmet County, Mich.

Locality 18a.—Bluffs on shore of Little Traverse Bay at P. M. R. R. station, Bay View, extreme NW. ¼ sec. 32, T. 35 N., R. 5 W., Emmet County, Mich.

Locality 21.—To right of Highway No. 11 at intersection of P. M. R. R., just east of East Bay View, NE. ¼ of the NW. ¼ sec. 34, T. 35 N., R. 5 W., Emmet County, Mich.

Regional and local structure play equally important parts in the presence and distribution of Traverse strata; but as a discussion of the deformation is to receive attention under a later heading the direct bearing of these two types of deformation on outcrops only need be mentioned here. To a broad southerly regional dip of indeterminable average intensity is due the appearance on the surface of the concentric Traverse belt. Local deformation of small magnitude but extreme complexity has so confused the general attitude that it is possible to state only the already well known fact, that to the north lower and lower rocks appear on the surface where the cover of drift has been removed, and that to the southward the Middle Devonian disappears from sight under the younger black shales and later beds to reappear again for the first time in northern Ohio.

As has been already mentioned,[12] a good part of the sequence may be learned from a close study of the more or less continuous ledge exposures on the south shore of Little Traverse Bay, where abundant and varying local doming brings to view now one, now another portion of the section. This method is, however, attended by difficulty and uncertainty, especially as regards exact measurement of thicknesses, and since the artificial uncovering through quarry excavation of much of the strata offers a much more ready means of observation, the shore exposures have been used in most cases merely as checks on lateral lithologic and stratigraphic variation.

[12] Pohl, E. R. Smithsonian Explorations Rept., p. 28, 1927.

The establishment of an almost unbroken series of depositional details from the basal exposed Traverse beds to the overlying Waverlian is one of the innovations of the present research, and in view of its initiation here it is desirable to present the details on which the conclusions are founded. For the illustration of the discussion immediately following the reader is referred to Plates 1 and 2, on which evidence and results are graphically represented.

In this presentation the normal method of investigation will be followed and the localities will thus become numerically disarranged when their sections are correlated so as to give a continuous succession from older to younger beds. Field determinations of lithologic "beds" and faunal "zones" are here retained, for they have both usually been found to be consistent over the area under discussion. The fossils particularly, although they may and often do have a greater geological range than is suggested by the places mentioned for them, are there especially abundant and serve as useful handles to characterize individual portions of the section.

The oldest known strata of Middle Devonian age in the western Lower Peninsula are exposed in a series of undulating ledges and low bluffs at water level on and south of Gravel Point, 1½ miles west of Charlevoix. The beds in this vicinity have a slight, generally southeastern dip. This general dip is, however, entirely regional, for the local structure is very complex. The entire region is underlain by more or less elevated domes and local anticlines and synclines which have an entire lack of consistent trend. The base of the section is to be seen in such a dome about one-eighth of a mile south of Gravel Point almost at water level. The sequence is then easily followed northeastward across the beach where the beds dip almost eastward to a low bluff which has been faced by a small quarry. The highest bed is found at Gravel Point in a small syncline or basin. Various zones of the section are excellently exhibited by reappearance at the surface along the shore the entire distance from Gravel Point to about a mile southward. The section exposed here in downward succession is as follows.

Geological section at Gravel Point (localities 8 and 8a)

Gravel Point stage.

Zone 4.—Light brown, cryptocrystalline, extremely massive, pure limestone with a conchoidal fracture, breaking easily in all directions into small fragments with sharp edges. In appearance like lithographic limestone, with no semblance of bedding planes. The fauna is not abundant but is quite varied, comprising a dumose *Favosites*, a small digitate *Favosites*, a distantly mammillated *Stromatopora*, small *Athyris*, large *Craspedophyllum*, costate *Stropheodonta*, and *Prismatophyllum*. A dark gray shale at the top carries abundant small *Stropheodontas* in particular. Thickness exposed -- 2 feet 6 inches.

Gravel Point stage—Continued.

Zone 3.—"Emmetensis zone."

Bed 2. This zone is a recurrence of the lithology and fauna of the lower part of zone 1. The rock is a thin-bedded, finely crystalline to semimassive, brown limestone and the fossils are beautifully preserved with the calcareous shells intact. Two and a half feet from the base is a slightly more shaley layer 3 inches thick carrying a solitary coral fauna in addition to the typical association. This bed is characterized by the large number of shells of a nacreous nature (*Pholidostrophia*), preserved with a pinkish color____9 feet 8 inches.

Bed 1. A sharp change in lithology accompanies the abrupt introduction of several new faunal elements, among which *Chonetes emmetensis* Winchell is the most conspicuous. The *Spirifer-Stropheodonta-Cystodictya* association continues in this bed along with the new introduction. The bed consists of a semimassive, flakey, buff-gray, shaley limestone, with a few long, reddish, organic markings, and has no true bedding planes. Frequent shale like layers a few inches in thickness separate the heavy limestones toward the base but the topmost foot and a half is composed of a practically barren, buff-gray, shaley limestone again with worm borings__4 feet 6 inches.

Zone 2.—"Large Atrypa zone."

Lower 12 inches lithologically similar to beds below but introducing a new association of species, consisting of a mucronate *Spirifer*, *concava-like Stropheodonta*, and *Cystodicyta*. Twelve inches above the base are seen many worm borings, and the character of the lithology changes to a brownish gray, very finely crystalline to massive, slightly shaley limestone. The lowest beds are seemingly reworked material filling in the interspaces between the reef heads below. The predominant sediment throughout this zone is of brownish-gray, massive limestone carrying numerous worm borings, but is interrupted at intervals by thin bands of semicrinoidal, crystalline limestone. In general, the entire zone carries a continuous fauna____8 feet.

Zone 1.—Base of exposed Traverse Group in western Michigan.

Bed 3. Dark brown, massive limestone in four bands nearly 1 foot thick each separated by thin, 2-inch beds of brown to black limey shale. Entire bed bituminous, very fossiliferous below with pelecypods, brachiopods, and individual corals. The top layer contains enormous heads of stromatoporoids, a small digitate *Favosites*, and many *Gypidulas*____4 feet.

Bed 2. Light brown to buff, shaley limestone introducing a predominating element of *Atrypa* and *Gypidula*, the latter often 2 inches in length. Several bands carry much bituminous matter 2 feet 6 inches.

Bed 1. Exposed in a dome on shore one-eighth mile south of Gravel Point. The basal bed is a dark brown to black, thin-bedded, shale-like limestone with an abundance of crinoidal fragments and crushed *Athyris*____1 foot 2 inches.

Above this is a lighter brown, fragmental limestone carrying a heavy coral fauna composed of *Prismatophyllum*, small digitate *Favosites*, *Stromatopora* (small mammillate type, mammillae about 2½ mm. apart), *Zaphrentis*, *Conocardium*, and *Athyris*_______2 feet.

Essentially the same succession is encountered in the next mentioned outcrop where in addition the sequence is extended through some 35 feet of younger beds. The effect of structure upon the

distribution of correlative portions of the succession is well appreciated when it is understood that only considerably higher beds than are observed in either outcrop are found between the two sections separated by a distance of fourteen miles. Further, a comparison of the depositional record as seen in the two areas will bear witness to a fairly widely extended continuity of both faunal and physical conditions.

Section at Petoskey Portland Cement Co.'s quarry (locality 14)

Gravel Point stage.

NOTE.—Zones 4 and 5 are exposed to best advantage to the west in the newer parts of the quarry (locality 14*a*).

Zone 5.

Bed 2. Very light gray, granular, fossiliferous limestone, same as exposed at locality 14*c* in similar position. To top of section__2 feet.

Bed 1. "Cherty" chipstone, lower part "mottled." Light to dark gray in color. Fossils scarce with one bed of *Favosites* noted_8 feet.

Zone 4.

Bed 4. Hard, black-brown, bituminous limestone with black shale partings several inches thick. Limestone in beds about 1 foot thick with fossils scarce; *Athyris, Atyrpa.* Corals common in shale at top: *Favosites, Prismatophyllum.* Costate *Stropheodontas* occur abundantly in black shale partings. One brownish black layer 1 foot thick near top contains a spectacular pelecypod fauna of undescribed species of *Ilionia, Leiopteria, Actinopteria, Janeia,* and a small *Leptodesma*-like new genus_________________6 feet 6 inches.

Bed 3. "Coral bed." Heavy coral bed with *Prismatophyllum* masses several feet in diameter. Grey-brown cryptocrystalline "chert" or chipstone (lithographic limestone), becoming granular at top with shallow depressions filled with black shale. Fauna: Digitate and turbinate *Favosites, Prismatophyllum, Zaphrentis, Atrypa, Athyris, Cryptonella, Crania,* and a costate *Stropheodonta*__1 foot 10 inches.

Bed 2. Brownish black "chert" (cryptocrystalline chipstone), in beds of moderate thickness with some black shale partings bearing corals and costate *Stropheodontas.* Several more granular, fossiliferous layers. One of these, 30 inches from top, contains *Proetus, Phacops, Asteropyge, Pterinopecten, Actinopteria, Aviculopecten, Stropheodonta concava* and *costata* types, a large, mucronate *Spirifer, Atrypa, Athyris,* and crinoid joints________________7 feet 6 inches.

Bed 1. Dull gray, fossiliferous limestone with shale partings, in beds about 1 foot thick________________________________13 feet 6 inches.

Zone 3.—"Emmetensis zone."

Gray limestone in regular, rather thick beds splitting in thin slabs on weathering. Nacreous fossils conspicuous, frequently possessing a pinkish color. Corals developed in irregular, reef-like structures along certain beds. Rock adjoining coral reefs granular. Fauna: *Chonetes emmetensis* Winchell, *Pholidostrophia,* mucronate *Spirifer,* solitary and colonial corals______________________________________14 feet 6 inches.

Zone 2.—"Large Atrypa zone."

Bed 3. Barren, light gray, compact limestone with shalelike partings of similar composition. Mottled and with iron-stained worm borings. 3 feet 6 inches.

Bed 2. Brown limestone carrying *Gypidula*________________11 inches.

Gravel Point stage—Continued.

Zone 2.—"Large Atrypa zone"—Continued.

Bed 1. Thick-bedded, gray limestone with shaley bands. Limestone breaks into thin beds on weathering. Fossils conspicuous on bedding planes. Fauna: Large *Atrypa*, *Stropheodonta concava* and *costata* types, mucronate *Spirifer*, *Cyrtina*, globose *Athyris* (almost limited to a single layer near middle) *Spirifer euryteines* type, *Douvillina* (rare), *Zaphrentis*, digitate *Favosites*____________10 feet.

Zone 1.—Chocolate-brown, hard, fine grained, resistent limestone with numerous fossil fragments and crinoid joints, in thick beds. Fauna consists mainly of *Gypidula*, *Prismatophyllum*, *Pholidostrophia*. Bottom not shown____________8 feet.

The sequence is then further continued in a section exposed in an old, abandoned quarry (locality 14*c*), about an eighth of a mile back from the shore of Little Traverse Bay and a mile west from the last-mentioned outcrop (locality 14). The section begins with the base of bed 2 of zone 5 seen near the top of the exposure at the Petoskey Portland Cement Co's quarry, and extends upward to a position near the base of the "Blue shale."

Section at abandoned quarry (locality 14c)

Drift covering.

Gravel Point stage.

Zone 6.

Bed 2. Equivalent to bed 2 of locality 14*e*. Dirty, bituminous, light brown limestone with bands of fucoidal markings. Fossils, especially *Prismatophyllum*, common. Thickness exposed____________10 feet.

Bed 1. "Lower Blue Shale." Fossils abundant, large numbers of costate *Stropheodontas*, *Atrypa*, digitate *Favosites*, *Prismatophyllum*, mucronate *Spirifer*, large *Spirifer*, *Athyris*, *Cyrtina*, *Fenestella*, and many encrusting, ramose, and flabellate bryozoa____________1 foot.

Zone 5.

Bed 8. Resistant, dark gray, fragmentally fossiliferous limestone with cryptocrystalline matrix weathering into large blocks. Fossils, especially *Favosites*, abundant at contact with lower shale. 2 feet 6 inches.

Bed 7. Fossiliferous black shale. Costate *Stropheodontas* abundant. *Atrypa*, *Fenestella*____________6 inches.

Bed 6. Corraline, fossiliferous, fragmental limestone passing horizontally into chipstone similar to that in bed 5 below. Reef conditions with large masses of corals conspicuous, and fossiliferous black shale partings. Fauna: *Prismatophyllum*, *Stromatopora* (distantly mammillated and nodose forms), dumose and digitate *Favosites*, of many varieties, *Cladopora*, Zaphrentids, and encrusting Trepostomes, *Atrypa*, *Gypidula*, *Cyrtina* (rare), *costate Stropheodontas*, *Proetus*. 12 feet.

Bed 5. Similar to beds 2 and 3 but darker and less slabby. Black shale parting several inches from top of bed. The upper surface of the bed consists of black shale, locally stained red and covered by an abundance of markings similar to worm borings, one-quarter to 1 inch in diameter, several feet long and depressed. Depressions filled with material from succeeding bed (bed 6); Fauna: Digitate *Favosites* and *Athyris*____________1 foot 6 inches.

Gravel Point stage—Continued.

Zone 5—Continued.

Bed 4. Granular, fragmental, fossiliferous limestone with *Stromatopora*, costate *Stropheodontas*. Fauna nearly same as in bed 6 above ---------- 6 inches.

Bed 3. Similar to bed 5 above ---------- 3 inches.

See covered interval ---------- 3 feet.

Bed 1. Base of section exposed. Very light gray chipstone (lithographic limestone). *Mottled*, due to leaching. Fossils sparse: *Atrypa* ---------- 5 feet.

About three-quarters of a mile farther west the sequence is again continued through younger beds, and with the inclusion of this last locality the character and thickness of the Gravel Point stage so far as exposed may be realized. Due to the incoherent character of the upper member of the Gravel Point stage and its tendency to break down quickly on exposure, this bed and its contact with those immediately following may seldom be studied.

Section at abandoned "Bell" Quarry (locality 14e)

Charlevoix stage.

Bed 4. "Dumose Favosites bed." Thickness exposed ---------- 4 to 9 inches.

Bed 3. "Laminated bed." Grey, coarsely crystalline, granular, porous limestone with the laminations, probably due to algal growth, decreasing in thickness upward and with the lower 2 inches and upper 6 inches unlaminated ---------- 2 feet 9 inches.

Bed 2. Pure, buff limestone of lithographic texture ---------- 1 foot 9 inches.

Bed 1. Reworked, fragmental clay shale ---------- 6 inches.

Gravel Point stage.

Zone 6.

Bed 3. "Blue Shale." Bluish-grey, incoherent, calcareous shale with numerous more coherent limey lenses. This bed quickly weathers to a sticky, gritless mud, carrying long selenite crystals and allowing the abundance of finely preserved fossils to roll free. The basal foot of this member is more pyritiferous than usual and carries a great number of small crushed *Conocardium emmetensis* Winchell. Fauna of entire bed; *Atrypa*, *Athyris*, costate *Stropheodonta*, *Prismatophyllum*, *Cystodictya* and many other bryozoa, and *Conocardium* are the most abundant ---------- 8 feet.

Bed 2. Same as zone 6, bed 2 of locality 14*c* ---------- 14 ft.

Bed 1. "Lower Blue Shale" ---------- 1 ft.

Section up to "Lower Blue Shale" is a duplicate of that at locality 14*c* -- 25 ft.

A hitherto unnoted section ties in with the upper portion of the two last-mentioned locations and carries the sequence still higher into the Charlevoix stage. This is one of the natural outcrops that preserves one of the most seldom seen Traverse phenomena—the contact between the Gravel Point and the Charlevoix stages. This section, on the shore of Little Traverse Bay at the Bay View Pere Marquette railroad station, was found to be the key to the entire problem of exposed Traverse sequential events, for it presents beds

for a considerable stratigraphic distance on either side of the contact and gives unquestionable evidence for the establishment of a continuity of sections at this previously debated position. The beds here have a rather strong (15°), local, average, easterly dip which gives a comparatively thick section in the limited exposure of the 15-foot bluff.

Geological section at Bay View railroad station (locality 18a)

Drift covering.

Charlevoix stage.

Bed 6. "Pelecypod-Gastropod Bed." Massive, thick, bedded, brown limestone, barren below, thin bedded above with large, discoid, lenslike inclusions. Thickness exposed ---- 7 feet, 4 inches

Bed 5. "Dumose Favosites Bed." Buff to brown, granular limestone with the leached corrals occurring in abundance in two bands and with the characteristic fauna continuing into the bed shown above as in the Curtiss quarry (locality 13). Top layer finely and unevenly laminated ---- 9 inches

Bed 4. Similar to bed 2 below ---- 1 foot 1 inch.

Bed 3. Massive, brown, bitumnnous limestone, breaking vertically into polygonal blocks ---- 1 foot 2 inches.

Bed 2. "Laminated Bed." Similar to that at following section (locality 13) ---- 1 foot 3 inches.

Bed 1. Bluish limestone with numerous, rounded sand grains. Material reworked from beds below with a few fragmental and worn fossils ---- 1 foot, 7 inches

Gravel Point stage.

Zone 6.

Bed 3*b*. "Blue Shale." Same as at locality 14*c* ---- 9 feet.

Bed 3*a*. "Conocardium Bed." Bluish grey, fragmental limestone, weathering brown. This is not a reef limestone, the corals being usually of solitary type. Preponderance of *Conocardium emmetense* Winchell, *Fenestellas*, *Cladopora*, *Favosites*, *Zaphrentis*, plicate *Gypiduta* ---- 12 to 14 inches.

Bed 2. Same as at localities 14*c* and 14*e*. Light brown, compact, bituminous limestone of reef composition. Isolated crystals of selenite occur throughout the matrix. Dominant fauna of reef corals and stromatoporoids, very numerous: *Prismatophyllum*, distantly and closely mammillated types of *Stromatopora*, *Conocardium*, costate *Stropheodonta*, *Atrypa*, and *Phacops*. Thickness exposed above water level ---- 4 feet 9 inches.

That there was at least a local withdrawal of the Traverse sea previous to the deposition of the Petoskey formation can not be doubted after a study of the unconformable relations of the Charlevoix and Petoskey beds to each other, especially in the section to follow. The reader is referred to the insert on Plate 2 for a graphic representation of the actual conditions of contact at this locality. The following section is chosen from the east end of the quarry so as to include the maximum thickness of Charlevoix beds which are elsewhere truncated by pre-Petoskey erosion.

Geological section at the Curtiss quarry (locality 13)

Petoskey formation.

Zone 2.—"Fenestella zone."

Bed 2. Similar to the crinoidal portion of zone 1 below, but carrying numerous broken fragments of Fenestellids. Thickness exposed. 6 feet 6 inches

Bed 1. This bed is made up of numerous layers of rather coarse, yellowish limestone, containing an overwhelming abundance of many Devonian types of bryozoa, but particularly the Fenestellidae, large and small *Spirifers*, and *Gypidulas*. The limestone layers are separated by fine shale partings..................................5 feet

Zone 1.—"Cyrtina-Gypidula zone."

The base of this bed, which is dirty throughout, is particularly fragmental. It lies unconformably and by overlap on the various beds of the eroded Charlevoix series. The lateral variation of the lithologic character, being made up at places throughout the thickness of the bed of coarse, crinoidal fragments, and at others of a finer, granular, dolomitic limestone, containing the typical association of the *Cyrtina-Gypidula* zone, indicates a differential sorting probably due to unstable conditions..............................0 to 12 feet

Charlevoix stage.

Bed. 9. Gray, fine-grained limestone with numerous cavities; breaking into small, angular fragments. Base stylolitic. Barren. Maximum thickness preserved..2 feet 6 inches.

Bed 8*b*. Similar to bed 8*a* in lithologic character, but unfossiliferous..1 feet 6 inches

Bed 8*a*. Coral layer containing same fauna as below but in exceeding abundance. Darker gray, less compact, more resistant, and less brittle than bed 8...6 to 9 inches.

Bed 8. Grey, lithographic, conchoidally fracturing chip-stone. Lower 6 inches finely and very unevenly and undulatingly laminated, dirty, granular, and porous. Fauna comprises a digitate and dumose *Favosites* and digitate *Stromatoporas*, a large *Stromatopora* and an *intermedia*-like *Ceratopora*..4 feet 8 inches.

Bed 7. Earthy limestone full of limonitic stains and containing wavy brown laminations. "Brown Bed"........................1 feet 3 inches.

Bed 6. Gray, partially porous and fragmentally grained, fine-grained limestone with numerous, thin, black, bituminous laminations. 1 foot 9 inches.

Bed 5. "Pelecypod-Gastropod Bed." Coarse, buff limestone in lower 3 feet, oölitic, with grains a milimeter or two in size, above. Two pelecypods, *Edmondia mactroides* Winchell and *Edmondia ledoides* Winchell and three gastropods, *Pleurotomaria cavumbilicata* Winchell, *P. emmetensis* Winchell, and *P. parvispira* Winchell are particularly abundant in, and are restricted to this bed..........................14 feet 6 inches

Bed 4. "Dumose Favosites Bed." Dolomitic, buff limestone with the typical fossil association of this bed as at Charlevoix Rock Products Co.'s quarry, etc..3 inches.

Bed 3. Massive, buff, dolomitic limestone, at places bituminous and laminar, with large discoidal lenses of fragmental limestone...........3 feet.

Bed. 2. Heavier, thin-bedded, shallow-water limestone with very uneven laminations and containing fine sand grain inclusions.............1 foot.

Bed 1. Thin bedded, uneven, bluish-gray limestone, frequently coated brown due to weathering of contained pyrite. Thin shale like partings with numerous minute sand grains..........................4 to 8 inches.

Gravel Point stage.

Zone 6.

Bed 3. Bottom of section exposed. The "Blue Shale" or uppermost bed of the Gravel Point was dug from a small test pit in the floor of the quarry bringing with it the typical association of fossils—10 feet.

The next section, to be seen near the east end of the town of Petoskey, completes the unbroken sequence in the stratigraphic record of the Traverse. Diligent search, which will be undertaken shortly, will in all probability result in the discovery of whatever beds may be unrepresented in the present succession. It is highly important that a complete succession be established, for such an unbroken record would have immediate usefulness in determining horizons in projected borings. It is highly improbable that any great thickness of beds is absent from the known sequence, for were that the case it would undoubtedly have been recognized in one or another of the numerous fortuitous quarry locations.

Geological section in quarry of Northern Lime Company (locality 18)

Top of section.

Petoskey formation.

Zones undifferentiated.

Bed. 3. Granular, fine-grained, light gray limestone in heavy beds, full of isolated *Stromatoporas*. Partings of black shale between bedding planes. Fauna: Digitate *Favosites*, encrusting *Stromatopora*, *Zaphrentis*, arbusculate *Favosites*, *Cylindrophyllum*, compound *Cystiphyllum*, *Gypidula*_________________________________7 feet.

Bed 2. "Cystiphyllum Bed." Light gray, compact limestone in two beds, breaking into small, angular fragments, Fauna: Digitate *Favosites*, *Zaphrentis*, *Atrypa*, *Athyris*, and *Cystiphyllum*______________________________________5 feet 9 inches

Bed 1. Fine-grained, brown limestone. The major portion of the thickness is composed of isolated, broken, and overturned *Stromatopora* heads, in some places filling the bed from top to bottom in reeflike structure. The interspaces between the reefs are filled with a thick-bedded, often foreset, matrix of fragmental, "coral sand." The thickness of the bed remains constant laterally. Fauna: Arbusculate *Favosites*, small-pitted and digitate *Stromatoporas*, and *Atrypa*____26 feet.

Zone 1.

Bed 1. Reworked layers between the cessation of erosion of the Charlevoix beds and the beginning of prolonged deposition (?). Generally a light gray, fine-grained limestone carrying small, angular, limey fragments and with many irregular, bituminous partings. Top bed muddy, carrying a lenticular pebble conglomerate. Upper surface of underlying bed irregularly eroded__________1½ to 3 feet.

Charlevoix stage.

Beds 6 and 7. Granular, dirty, brown limestone full of wavy, bituminous laminae. Single bed__________________________________3 feet 6 inches.

Bed 5. "Pelecypod-Gastropod Bed." Gray-brown, very fine-grained limestone. Massive and with conchoidal fracture___________________12 feet.

Having thus established an unbroken succession through some 200 feet of beds, any portion of which is easily distinguished from another through all exposed sections in Charlevoix and Emmet Counties, it becomes necessary to find a place for a faunally, lithologically, and geographically isolated 16-foot outcrop near East Bay View. This exposure in a small, abandoned quarry is, so far as known, the easternmost surface indication of Traverse rocks in Emmet County. Much of the contained fauna bears a superficial resemblance to species restricted to portions of the Gravel Point stage; but when compared a wide difference both between species and association becomes quickly apparent. The singular absence of the highly characteristic and ever-present Gravel Point *Prismatophyllum anna* (Whiteaves) argues strongly against a correlation with any portion of these beds. The presence, however, of the coral *Cylindrophyllum panicum* (Winchell), whose only other known occurrence is high in the Petoskey formation, in these beds, indicates a close relationship to the Petoskey formation. From both stratigraphic and faunal standpoints, the section following must be intercalated in the thus partly filled gap within the Petoskey. The Norwood, Charlevoix County, section (to be described later) is the only occurrence at present known where the highest beds of the Petoskey formation are seen to rest in contact with the succeeding Waverlian black shale. Since, then, the complete succession of Traverse beds is known, with the single exception of the break within the Petoskey under discussion, the probably correct position for this debatable outcrop is within that break. The only other possible suggestion, that it is a lower set of beds than is to be seen elsewhere at the surface is strongly denied by the close relationship between its contained fauna and that of the Petoskey formation.

Geological section east of East Bay View (locality 21)

Petoskey formation.

Zones undetermined.

Bed 10. Gray, shalelike limestone. Long, solitary corals. Thickness exposed____8 inches.

Bed 9. Fissile, black shale with minute, irregular limestone lenses and fossils weathering reddish. Fossils in shale few and crushed. Fauna: *Pharcops* cf. *rana*, large *Spirifer* (*eurytines* type), mucronate *Spirifer*, *Stropheodonta erratica* and *demissa*, *Ceratopora* (large longitudinally striate), ramose bryozoa, *Fenestella*, *Cyrtina* (flat area, curved at beak), *Cylindrophyllum*, *Hederella*, digitate and arbusculate *Favosites*, and *Cranaena*_______________2 feet 4 inches.

Bed 8. Dark gray, bituminous, comparatively heavy limestone in eight-inch layers with large fucoids on fossiliferous shalelike partings. Shales composed of fossil fragments, probably deposited under more turbid water conditions. Fauna, especially the corals, abundant. Arbusculate and digitate *Favosites*, mucronate *Spirifer*, *Gypidula*, *Stropheodonta erratica* and *demissa* types, numerous frondose bryo-

Petoskey formation—Continued.

Zones undetermined—Continued.

zoa, crinoid joints, two species of *Cyrtina*, *Taeniopora*, many types of *Stromatopora*, *Aulopora*, *Striatopora*, *Certopora erecta* type, *Cystiphyllum*, *Cylindrophyllum panicum* Winchell, and a smaller species, *Fenestella*, *Atrypa*, *Athyris*, *Cranaena* (with fine color bands), *Pholidostrophia* (flexed type), *Conocardium* species, *Phacops*, *Athyris*, and *Cystodictya*--3 feet 6 inches.

Bed 7. Soft, fissile, black shale without fossils, containing inch-thick calcareous lenses with *Spirifer* cf. *mucronatus*, and *Fenestellids*, --6 inches.

Bed 6. Buff, fine-grained, fragmental limestone in single bed becoming shaley at top. Mucronate *Spirifer* (most common), *Favosites* (arbusculate type), *Ceratopora*, *Heliophrentis*, *Aulopora*, many Trepostomes, *Stromatopora* (*Idiostroma* type), *Gypidula*, *Stropheodonta erratica*, digitate *Favosites*, *Phacops* species and *Striatopora*---3 feet.

Bed 5. Crinoidal, fragmental limestone in thick beds, bluish grey weathering brown. Fauna as below with new elements, i. e., small *Cyrtina*, *Fenestella*, large, high-areaed *Spirifer*, and numerous species of Trepostomes--- 5 feet.

Bed 4. "Gypidula Bed." Slightly calcareous shale doming in floor of quarry. Extremely fossiliferous but with few species. Great abundance of *Gypidula*, fine lined *Spirifer*, large, mucronate *Spirifer*, deeply sulcate *Athyris*, broad fronded *Cystodictya*------Quarry floor.

At the top, as at the base, of this section there is again an hiatus of undetermined extent between it and the next succeeding continuous section. Unfortunately for the study of the stratigraphic succession in this area the thick covering of drift to the south of the narrow belt of hard-rock formations bordering Little Traverse Bay hides the uppermost beds of the Traverse group. These are exposed at but one locality, near the Antrim—Charlevoix County line just north of Norwood. This exposure is, incidentally, at the same time the westernmost and southernmost outcrop of "in situ" Traverse rocks in western Michigan. The location of rocks of this age in Benzie and Leelanau Counties and on the Manitou Islands on the State geological map is purely inferential.

Geological section on shore of Lake Michigan, 1 to 2 miles northwest of Norwood (locality 7c)

Running north along the shore of Lake Michigan for about a mile from a point nearly a mile northwest of Norwood are beds dipping in a southwest direction and forming bluffs at its northern edge of exposure of nearly 15 feet in height above lake level. A point at the northern end of exposure, extending slightly into the lake, exhibits the lowest beds of the section dipping at an angle of about 20° to the south. These beds carry an abundance of small *Atrypas*. Lithologically there is no distinct difference between these layers and the next succeeding, which are, however, characterized by numerous digitate *Favosites*. The basal foot and a half of this latter bed is practically barren and is composed of a light grey, dirty, limey shale, but the upper 6 inches are full of fossils, the upper surface of the bed being covered with

sinuate, usually horizontally compressed fucoids having an average diameter of one-half inch. Passing to the south, some 30 feet of thin bedded, finely crystalline dolomites interbedded with irregular, nodular bands of chert are exposed, due to the southerly dip, in several low bluffs. Near the top of these beds (the "Cherty Beds" of Winchell), are several 1-foot bands of coarse dolomite containing several corals (*Heliophyllum*, *Favosites hamiltoniae* (?), and a questionable *Cladopora*) and a large *Atrypa*. Near the southernmost exposure some large "kettles," radially arranged anthracolite concretions having as a usual nucleus an arthrodiran plate, weathered from the immediately succeeding Waverlian black shale were observed, but no black shale was seen in contact with the underlying Petoskey beds.

The sections as thus combined to give a complete succession for the Traverse Bay district aggregate approximately 250 feet in exposed beds. It is, of course, impossible to even hint at the thickness of the unexposed portion of the Petoskey. It is hoped that further search will bring to light the beds to fill this gap; but for the present it seems probable from attendant circumstances that these will not extend the section very considerably. From a study of the physical relations this volume of deposition is found to be unequally apportioned between three divisions—120 feet in the Gravel Point stage, 28 feet for the Charlevoix stage, and 100 feet for the Petoskey formation, which latter may be increased if the unknown beds are later discovered.

Physical criteria bearing on the restriction of stratigraphic units.—It has been shown that throughout the thickness of beds below the "Blue Shale" there have been common recurrences of a certain number of lithologic characteristics. To sum these up connectedly there has been a singular absence of the coarser clastic materials, especially the silicates, while there is a frequent alternation of fine, gritless shales with the shaley and compact limestones. Fossiliferous black shale partings are particularly abundant toward the middle of the Gravel Point section, while toward the top fine, blue, clayshales become increasingly apparent. A great majority of the sediments are made up of the darker, compact limestones which in many cases are strongly bituminous. Cryptocrystalline limestones with a lithographic texture comprise much of the beds near the middle of the series. Reef structures of limited vertical and lateral extent are one of the commonest features throughout the Gravel Point. While the distinction between lithologic layers is usually sharp there is not the slightest suggestion of broadly unstable conditions within the series. The vertical lithologic variation is to be explained rather on the basis of differential, not too shallow water current sorting and the tendency on the part of the sediments to fill in the depressions between the comparatively rapidly developing *Prismatophyllum* and *Stromatopora* reefs.

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At present there are too few occurrences of the "Blue Shale" known to be able to state definitely the amount of variation in its thickness nor to what cause this variation is due. It is now known to range between 6 and 11 feet at different localities. The upper surface wherever seen is slightly undulating; but whether this undulation was caused by sub-aerial or sub-marine erosion it is impossible to determine with the information now at hand.

The sudden introduction in the Charlevoix stage of an entirely new and unprecedented set of physical and lithological conditions is in itself sufficient to make one suspect an erosional break at its base. Throughout the first 2 or 3 feet (in some places greater, see locality 13), of beds in the initial Charlevoix deposition, wherever seen, there is a considerable abundance of fine, rounded quartz grains interspersed more or less evenly through a granular reworked matrix containing numerous worn and broken shell fragments. As a whole the Charlevoix series is characterized by fragmental deposition throughout, frequent occurrences of bituminously laminar beds, the presence of a coarse, calcareous oölite near the middle of the section, and the recurrence of fine grained beds at the top.

The most interesting physical feature of the Charlevoix is, however, the character of its upper surface. For a study of this phenomenon the reader is again referred to the inset on Plate 2 and the geological section taken at locality 13.

At the Curtiss quarry (locality 13), a section through the entire thickness of the Charlevoix stage may be taken and here also may be seen the highest beds belonging to this division visible anywhere in the district. The thickness of this series from the base of bed 1 to the top of bed 9 is slightly short of 28 feet. The preceding beds comprise the Charlevoix series in their greatest preserved development. In the face of the quarry, running in a northwesterly direction, these beds are cut in downward succession by a distinct and pronounced, irregular, angular unconformity. Evidence points to a considerable time interval during which there was much erosion of the Charlevoix series. During the emergence, at various places and in particular the west end of the locality 13 quarry and west along the present lake shore, beds 9, 8*b*, 8*a*, 8, 7, 6, and a few feet of the preceding "Pelecypod-Gastropod Bed," bed 5, were in some places partially, in others completely, removed by erosion. This, like most of the quarries in the region, is situated in the center of a longitudinal dome or anticline, and it is probable that during the post-Charlevoix emergence the beds were domed and then subjected to an irregular peneplaning effect. Accompanying this folding was a slight readjustment by faulting which is well exhibited in the south face of the quarry. This fault has a vertical throw of about 6 inches which does

not continue into beds of the Petoskey formation although it can be easily traced through all the members of the Charlevoix. This can not be explained on the basis of incompetency, for if anything the beds of the Charlevoix are more competent than those of the Petoskey. Nor can it be dismissed by an argument based on "cushioning" for the basal beds of the Petoskey are compact and easily fractured. As if to further substantiate the importance of the unconformity there is a complete change of faunal and lithological characters above the break. In a series of small quarries, bluffs, and ledges near water's edge, forming a continuous exposure of a mile in length to the east of locality 13, the contact between the Charlevoix and the Petoskey series is exhibited at an almost constant height above lake level throughout the length of the exposure. The crinoidal Cyrtina-Gypidula zone of the Petoskey here rests on the irregularly eroded surface of one or another portion of the Pelecypod-Gastropod bed (bed 5) of the Charlevoix. We may thus see that the removal of beds from the top of the Charlevoix stage was not of restricted character, for over considerable distances *there is a known deletion by erosion* of between 12 and 15 feet. It is extremely probable that even greater thicknesses were deposited during Charlevoix time and subsequently denuded, but to what vertical extent can not be ascertained.

The acceptance of the proof presented requires not only the withdrawal of the sea at the end of Charlevoix deposition, but also the emergence of the area for the minimum time necessary for the consolidation of the beds and for the removal of at least 15 feet of mostly tough limestones, before the earliest local encroachment by and deposition in the Petoskey sea.

This contact is again shown to excellent advantage in two other sections and since the importance of this phenomenon can not be underestimated it would be better to include a discussion of their peculiar characteristics here.

In a now abandoned quarry (locality 15), nearly 2 miles west of locality 13 on Nine Mile Point (near center sec. 2, T. 34 N., R. 7 W., Charlevoix County), bed 9 of the Charlevoix stage again exhibits the effects of erosion. This bed is here composed of a massive white limestone with numerous solution cavities, probably due to leaching contemporaneous with the pre-Petoskey denudation. This highest member of the Charlevoix section is deeply gutted and channeled, and the initial deposit of the Petoskey, a course shale about three-quarters of an inch thick, rests on the unevenly eroded surface of the beds beneath. The filling of the irregularities in the underlying series is completed by a fragmental, shaley limestone carrying overturned heads of a small-pitted *Stromatopora* and broken *Gypidula*

shells. The first continuous layer of the Petoskey series is a non-bedded, dirty, fragmental limestone with *Gypidulas* followed by a fossiliferous sand rock. The same upper member of the Charlevoix (bed 9) is again seen in irregular contact with the lowest Petoskey farther west at the junction of State Highway No. 11 and the Walloon Lake Road (south extreme of section line between secs. 1 and 2, T. 34 N., R. 6 W., Emmet County, locality 16), where conditions similar to those just described for locality 15 are to be observed.

At the beginning of Petoskey time conditions were still very unstable, as is evidenced in the lateral variation of single beds, in the overlap by others, and in general by a series of fragmental limestones at the base. There is, moreover, in a certain fragmental, crinoidal coquina excellent indication of shallow water conditions in the foreset, cross-bedded bedding planes near the base of the section. Through the lower 30 or so feet of the Petoskey series are continuing indications of sedimentation within the range of current or wave action. This is especially to be seen in the fragmentary character of the abundant reef-forming *Stromatopora* heads, which more often than not lie disconnectedly and in abnormal position in the fragmental matrix of calcareous sand. These have in most cases been violently broken away from their original connections and distributed at varying distances from them. The middle of the section again shows in its compact and evenly bedded, fine grained limestones and shales a return to normal and steady marine deposition in the area. The introduction in the upper portion of the section of an abundance of colloidal silica in the form of segregated and banded chert argues strongly for a return of the area to a condition which was affected by shore influences and a mingling of land waters carrying silica in suspension with the saline waters of the epeiric sea. This is further emphasized by the occurrence of dolomite in these beds, for it is a known fact that calcium and particularly magnesium are especially effective in the precipitation of colloidal silica. The necessary carbon dioxide was of course produced by the presence of abundant invertebrate life.

At the present time the actual contact between the Traverse and the succeeding black shale has not been seen so that the physical conditions of juxtaposition may not be remarked upon.

FAUNAL INDICES OF THE STRATIGRAPHIC UNITS

The present status of paleontologic knowledge of the Traverse will for some time necessitate the use of rather broad and generalized statements. By far the greater majority of the organic remains preserved in these strata is still undescribed, and those already described and identified have not been sufficiently compared for

correlation purposes with biological relatives found elsewhere. The present section will therefore deal only with the general phases of the subject being limited to a discussion of those distinctive species known to have a restricted occurrence within one or another of the three stratigraphic units of the Little Traverse Bay district. Throughout the sequence fossil remains are legion, but fortunately for stratigraphic discrimination a number of species and several genera have, as usual, a limited range in the succession, and may thus be used as criteria for a ready and undeniable determination of exposed portions of the section.

Indications of the existence of sponges in the Traverse are rare, and yet in several beds numerous, long, monaxon spicules of an unidentifiable Silicisponge are found. The most notable of these occurrences is at the top of the section at locality 21 (middle Petoskey).

No attempt will be made here to give the ranges and restrictions of the numerous species of the Hydrocorallines, algae, and sponges included under the general term "*Stromatopora*." Several of them have been described but they have never been studied in regard to their stratigraphic position.

From a stratigraphic and biologic standpoint the best understood organic remains of the Traverse series are the corals. This is due to the work of Grabau, and from his unpublished manuscript (1915), is derived the following summary of the positions occupied by a number of closely discriminated species. So far as is now known the species cited for the various units are restricted to them respectively.

Petoskey formation:

Stereolasma cf. *recta* (Hall).
Heterophrentis cf. *prolifica* (Billings).
Pinnatophyllum scyphus (Rominger).
P. scyphus carinatus Grabau (chironym).
Cyathophyllum robustum Hall.
C. subrobustum Grabau (chironym).
Merophyllum kegomigense Grabau (chironym).
Pristiphyllum longiseptum Grabau (chironym).
Cylindrophyllum panicum (Winchell).
C. magnum Grabau (chironym).
Cystiphyllum cf. *vesiculosum* (Goldfuss).
C. conifollis Hall.
C. varians Hall.
C. aggregatum Billings and *aggregatum caespitosum* Schlüter.
Aulopora serpens Goldfuss.
Ceratopora cf. *jacksoni* Grabau.
Syringopora crassata Winchell.
Favosites transitorius Grabau (chironym).
F. alpenensis dumosus Winchell.

Charlevoix stage:

Heterophyllum alpenense Grabau (chironym).
Pachypora limitaris (Rominger).

Gravel Point stage:

Merophyllum cysticum (Winchell).
Prismatophyllum davidsoni michiganense Grabau (chironym).
P. anna (Whitfield).
Chonophyllum ponderosum Rominger.
Aulopora alectiforma (Winchell).
A. aperta Winchell.
A. *conferta* Winchell.
A. cyclopora Winchell.
Ceratopora partita (Winchell).
C. fenestrata Winchell.
Alveolites subramosus Rominger.

Although most of the beds of the Traverse series offer abundant evidence of the existence of a varied crinoid association, identifiable remains are among the rarest occurrences. A few poorly preserved calices of a species of *Megistocrinus* found low in the Petoskey are the only notable exceptions.

Through many of the beds are also found abundant and beautifully preserved fossils of bryozoa. The Cryptostomes are especially numerous, and these are at the present time undergoing revision and discriminating study by C. F. Deiss, formerly of the University of Michigan. Most of the other forms in the Little Traverse Bay area have received little attention. Of the described forms with known limited range only *Cystodictya sulcata* Winchell from the lower part of the Gravel Point may be cited.

Brachiopods are a very common element of the faunal associations. Among them are a number which may be mentioned as characterizing the individual units.

Petoskey formation:

Stropheodonta erratica fissicosta Winchell.
S. demissa forticosta Winchell.
Chonetes cf. *coronatus* (Conrad).
Spirifer filicosta Winchell.

Gravel Point stage:

Stropheodonta erratica solidicosta Winchell.
S. near *concava* Hall.
Douvillina cf. *inaequistriata*, (Conrad).
Chonetes emmetensis Winchell.
Spirifer mucronatus longispina Grabau, (chironym).
S. bidorsalis Winchell.
Athyris eborea (Winchell), var.

Nowhere in the section are the mollusca particularly well represented. Of the pelecypods the only notable representative in the Petoskey beds is a single species of *Conocardium*, *C. bifarium* Winchell. The Charlevoix series is characterized by a profusion of two doubtful species of *Edmondia*, *E. mactrodies* Winchell and *E. ledoides* Winchell. Scattered individuals of a few undescribed species are found in several zones of the Gravel Point. The following forms

are restricted to the lower unit: Several undescribed species of *Actinopteria*, *Janeia* species, *Paracyclas* species, and *Conocardium emmetense* Winchell. Of the gastropods the only remarkable forms are three species of *Pleurotomaria* (?), *P. cavumbilicata* Winchell, *P. emmetensis* Winchell, and *P. parvispira* Winchell, known to be limited to the Charlevoix; and a septate form of *Euomphalus* found low in the Petoskey. Cephalopods are present but not commonly so, and have received little or no attention.

Of the trilobites, species of *Phacops*, *Proëtus*, and *Asteropyge* occur in both the Gravel Point and Petoskey. These have not so far been studied. Ostracods of the *Moorea* and *Beyrichilina* types are found in the Gravel Point and are abundant in some beds of the Charlevoix but again have not been differentiated nor described.

Occasional fish plates of the *Dinichthys* and *Ptyctodus* types are found in isolated occurence, but their rarity precludes any stratigraphical usefulness.

REGIONAL AND LOCAL STRUCTURE

Much has already been said concerning the varied and complex structure of the region bordering Lake Michigan. With the additional evidence now in hand several new features appear to further complicate any intrepretation of these phenomena.

Deformation versus reef origin.—It appears unquestionable that the miniature closed anticlines and synclines which are so abundant at all exposures of the Traverse beds in western Michigan are due to an entirely local and indigenous cause. The positions of numerous, compact *Prismatophyllum* and *Stromatopora* reefs are seen to be geographically and stratigraphically fortuitous, and upon consolidation the strata would naturally conform to the irregularities caused by these more compact masses. Reefs of large dimensions are, however, entirely absent, and for the explanation of the larger domes, anticlines, basins, and synclines we must look to other causes. One undoubted emergence and probable deformation on a slight scale has already been shown to have occurred within the Traverse. The oscillating character of the central basin portion of the Devonian province has just begun to be appreciated. The regional dip has been remarked before as trending irregularly southeastward. Faunal discrepancy between the western and eastern areas of Traverse outcrop is becoming more and more evident as the associations become increasingly understood. It is rather difficult to account for this faunal distinction on any other basis than the hypothecation of at least an intermittent land barrier separating the two regions. This supposition requires a remodification of structural attitudes to account for the present day regional structure.

THICKNESS OF THE TRAVERSE GROUP IN WESTERN MICHIGAN

So far as is known from the combined well records and exposures in the western portion of Michigan there is no great thickness of continuous shale deposition above that at the base of the Traverse. This bed of shale, to which the term "Bell Shale" has been applied in well records in conformity with the occurrence in eastern Michigan of a similar stratum resting on the Dundee, varies according to reports from 40 to 100 feet in thickness. In later and more reliable records this "Bell Shale" is seen to maintain an average thickness of nearly 70 feet, its lower boundary being drawn at the contact, with great lithologic change, with the "Dundee."

Paradoxically enough the most useful of the numerous well records is one of the earliest and least detailed reports, but its location is accurately described and it was begun in beds having a determined position in the stratigraphic sequence. Fortunately this early record gives sufficient information, having penetrated to the Bell Shale, to make possible an estimate of the complete thickness of Traverse rocks deposited in western Michigan. This record has been already published,[13] but for convenience of reference it is again cited.

Location: Sec. 33, T. 35 N., R. 5 W., Bear Creek Township. 120 paces northwest from door of G. R. & I. R. R. station and 40 feet from shore of Bay. "Bay View well."

Elevation: 585 feet above sea level.

Completed July, 1895.

	Thickness, feet	Depth, feet
Pleistocene: Shingle	4	4
Devonian:		
Traverse group—		
Cream limestone	260	264
Medium grey limestone	198	462
Dark limestone	11½	473½
Cellular blue clay (Bell Shale)	25	498½

The mouth of this well is situated at or about the contact between the Gravel Point and the Charlevoix stages. The tools are recorded as encountering the "Bell Shales" at about 470 feet. If to this we add the average 70 feet of the Bell and the minimum known thickness of rocks above the mouth of the well (130 feet), the entire thickness of the Traverse is here shown to have a minimum of approximately 660 feet, proving the existence of more than 400 feet of unexposed Traverse beds underlying the region.

Computations from the records of other wells at various localities in Charlevoix and Emmet Counties substantiate the estimate of the thickness of the western Traverse beds derived from the Bay View

[13] Grabau, A. W. Mich. Geol. Survey Ann. Rept. for 1901, p. 197, 1902.

well. The succession varies in development between 669 and 670 feet of actual and estimated thickness in the two following wells: Boyne City, Northwestern Michigan Development Co., J. M. Stutzman well No. 1, located in the SE. 1/4 of NW. 1/4 of sec. 16, T. 33 N., R. 6. W., Evangeline Township, Charlevoix County; and the Petoskey municipal well, located near the city waterworks in the bottom of Bear River "gorge" a short distance from Little Traverse Bay, Petoskey, Emmet County.

LAKE HURON SEQUENCE

A restudy of the eastern Michigan Traverse has been undertaken by the geological survey of the State, but further details of this succession must await the completion of field studies. Until recently the sections have remained as they were described by Grabau in 1901,[14] with the exception of a discussion of Grabau's newly proposed Presque Isle series.[15]

Before proceeding to a faunal comparison of the sections exposed in the western and eastern portions of Michigan a brief summary of the existing stratigraphic knowledge of the latter area is appropriate.

The fourfold subdivision previously adopted for the Traverse group in Presque Isle and Alpena Counties has more recently been restricted by Grabau, the Bell Shales now forming the lowest member of the Presque Isle series. The sequence in downward succession as now understood is as follows.[16]

	Feet
Thunder Bay series (stage)	137–190
Alpena series (stage)	118–134
Presque Isle series (stage):	
Long Lake beds (member)	157–169
Grand Lake limestone (member)	39– 39
Bell Shales (member)	60– 80
Total Traverse group	511–612

The contact phenomena of the various stages of the thus subdivided Traverse group in eastern Michigan have not so far undergone close study, but widely different lithic and petrographic characters are found by rock analysis to be constant through each of the divisions. A tabulation of the available analyses will show the percentage range of the major constituents of samples taken from various portions of the succession.

[14] Grabau, A. W. Mich. Geol. Surv. Ann. Rept. for 1901, pp. 175–196, 1902.
[15] Grabau, A. W. Unpublished manuscript, pp. 290–308, 1915.
[16] Grabau, A. W. Unpublished manuscript, pp. 298, 308, 318, 441, 1915. Notes of Mich. Geol. Surv. Expedition, 1926.

A. Analyses of various beds of the Thunder Bay stage show

	Minimum		Maximum	Average
SiO_2	21.54	to	55.86	48.43
Fe_2O_3	4.66	to	5.11	4.89
Al_2O_3	4.58	to	20.93	16.19
$CaCO_3$	3.18	to	60.89	24.90
$MgCO_3$	2.57	to	5.94	3.70

B. Analyses of various beds of the Alpena stage give

	Minimum		Maximum	Average
SiO_2	0.20	to	4.62	1.39
Fe_2O_3	.13	to	.53	.30
Al_2O_3	.13	to	1.79	.75
$CaCO_3$	89.20	to	99.63	96.69
$MgCO_3$	.21	to	8.61	1.71

C. Analyses of various beds of the Presque Isle stage give

	Minimum		Maximum	Average
SiO_2	28.38	to	66.39	52.10
Fe_2O_3	1.59	to	5.87	3.49
Al_2O_3	7.23	to	20.44	13.82
$CaCO_3$	9.12	to	33.00	21.06
$MgCO_3$	.50	to	5.02	2.15

The foregoing tables make no pretense at completeness of statistics, nor are the computed averages of strictly quantitative nature for the entire thickness of any of the stages. They will, however, serve to bring out the strong contrast in the quantative character of the rock constituents in the three series of beds and explain the restriction of the cement industry to beds belonging to the middle division.

Distinctive species of the eastern Traverse.—As with the organic remains of the Traverse Bay section the greater majority of fossils found in the Traverse beds of eastern Michigan have as yet received little or no discriminating attention. A full discussion of the faunal character of associations in the various portions of the section must await the completion of considerable paleontologic study. Ready means for distinguishing between the broader divisions of the succession is, however, afforded through the restriction of a number of abundant and easily recognized species to one or another of the three stages. So far as known the species mentioned below have not been found elsewhere in the sequence than in beds of the stage under which each is respectively cited.

Species characteristic of the Thunder Bay stage

Stereolasma cf. *recta* (Hall).
Zaphrentis (*Homalophyllum*) *exigua* (Billings).
Pristiphyllum longiseptum Grabau (chironym).
Cylindrophyllum cf. *panicum* (Winchell).

Eridophyllum cf. *strictum* Edwards and Haine.
Cystiphyllum arboreum Grabau (chironym).
Ceratopora cf. *partita* (Winchell).
Favosites placentoides Grabau (chironym).
F. nitella Winchell.
Cladopora (*Coenites?*) *fisheri* (Billings).
Trachypora elegantula Billings.
T. (?) *proboscidialis* (Rominger).
Alveolites subramosus Rominger.
Scalaripora separata Ulrich.
S. approximata Ulrich.
Camerotoechia cf. *gainesi* (Nettleroth).
Cimitaria, new species near *corrugata* (Conrad).
Plethomytilus cf. *oviformis* (Conrad).
Nucleocrinus species cp. *obovatus* (Barris).
New species cp. *meloniformis* Barris.
Heteroschisma gracile Wachsmuth.
Pentremitidea americana Barris.
Gennaeocrinus cassedayi Lyon.
Megistocrinus concavus Wachsmuth.
M. multidecoratus Barris.
Dolatocrinus triadactylus Barris.
Stereocrinus cf. *triangulatus* Barris.

Species characteristic of the Alpena stage

Pinnatophyllum multilamellatum (Nicholson).
Merophyllum (?) *conatum* (Hall).
Prismatophyllum anna (Whitfield).
P. cristatum (Rominger).
Chonophyllum ponderosum Rominger.
Cystiphyllum cf. *aggregatum* Billings.
Microplasma alpenense Grabau (chironym).
Aulopora serpens minuta Grabau (chironym).
Favosites cf. *hamiltoniae* Hall.
F. radiatus Rominger.
F. alpenensis Rominger .
Cladopora robusta Rominger.
C. expiata Rominger.
Alveolites cf. *goldfussi* Billings.
Michelinia insignis Rominger.
Stropheodonta cf. *concava* Hall.
Chonetes cf. *mucronatus* Hall.
Spirifer cf. *pennatus* (Owen).
S. cf. *granulosus* Hall.
Nephriticerina alpenensis Foerste.
Acleistoceras casei Foerste.
A. nummulatum Foerste.
Alpenoceras ulrichi Foerste.
Numerous criniods of the genera *Megistocrinus* and *Dolatocrinus.*

Characteristic species of the Presque Isle stage

Heterophrentis prolifica (Billings).
H. convoluta (Hall).

Zaphrentis (?) *gregaria* Rominger.
Aulacophyllum princeps deflecta Grabau (chironym).
Blothrophyllum rabiteaui Grabau (chironym).
Pinnatophyllum scyphus (Rominger).
Heliophyllum coalitum (Rominger).
Prismatophyllum nanum Grabau (chironym).
Ceratopora near *jacksoni* Grabau.
Favosites placenta Rominger.
F. radiciformis minus Grabau (chironym).
Trachypora near *limbata* (Eaton).
Chonetes fragilis Stewart.
Spirifer prolificum Stewart.
Spirifer near *oweni* Hall.
S. johnsoni Grabau (chironym)
Leiorhynchus lucasi Stewart.
Grammysia cf. *nodocostata* Hall.
Lophonychia, 2 new species.
Pterinea near *flabella* (Conrad) and several varieties.
Phacops milleri Stewart.

DISCREPANCIES IN FAUNAL DISTRIBUTION

There can be no reasonable question as to the general age equivalence of the Traverse group as developed in western and eastern Michigan. Although a heavy drift cover conceals the actual continuity of beds between the two areas, records of wells sunk at various intervals entirely across the region immediately underlain by Middle Devonian rocks establishes the fact that throughout its extent across the northern portion of the Southern Peninsula the Traverse group maintains a thickness close to 700 feet. It is further inconceivable in a region of such comparatively shallow warping that any great thickness of beds deposited in Traverse time was completely removed before the initial invasion and deposition by the early Waverlian sea which soon completely buried the underlying rocks. This explanation might be read into the southward thinning of the Traverse beds and the absence in northern Ohio of later Traverse deposits; but abundant evidence is found in the same paleogeographical basin in Ohio and Indiana farther south of continuing Devonian sedimentation. This fact would deny the necessary time for the removal in great part of a continuous sheet of Traverse limestones to the northward of the latter area. The Upper Traverse is absent in northern Ohio rather through nondeposition and off-lap to the northward. Why then is there no faunal connection between the two areas in which the greatest known succession of Traverse beds was developed? The question can not be answered with the data available at present, and is presented with the hope of stimulating further work on this puzzling problem of faunal distribution.

Study of the whole area of Traverse outcrop has brought to light only normal conditions of sedimentation throughout the group, and

yet there is not a single faunal association common to the eastern and western areas of outcrop. The individual species, too, although belonging in most cases to the same generic and family types, with few exceptions, are distinct in the two regions. To my knowledge not a single highly diagnostic species of any portion of either the eastern or western sections has been found at any place in the other. To be sure, a number of so-called "species" have been identified as occurring alike in the two sections, but for correlation purposes these invariably turn out to be utterly useless on critical examination. Like "*Atrypa reticularis*" they may be "species" with long life histories; or like "*Pholidostrophia iowensis*" they, may have insufficient characters for useful discrimination; or with others like "*Phacops rana*," "*Spirifer mucronatus*," "*Stropheodonta concava*," and dozens more, the name may be merely a jack-pot fed by constantly increasing numbers of indifferently and carelessly identified forms. We are never to arrive at any exact knowledge of true conditions by using *these* "species" for otherwise careful consideration of the problem.

FALLACIES OF CORRELATION AND EVIDENCES FOR PROPER POSITION IN THE GENERAL TIME SCALE

Previous expressions of opinion concerning correlation of the Traverse beds has almost uniformly favored their time equivalence with the "Hamilton" of New York State. That the "Hamilton" of that State comprises several distinct stratigraphic units characterized by distinct faunal associations of different time values has been only recently understood.[17] The combined faunas of beds ranging from the Marcellus to the Tully were grouped and the result was a "typical Hamilton fauna." From this enormous association similarities were drawn with a comparatively few Traverse representatives. Accounting for the absence of diagnostic Hamilton fossils of even the "percentage scale" forms in the Traverse was either disregarded or explained on the basis that westward migration for these species (and in the same way the vast majority) was in some way hindered.

The presence of forms unknown to the Middle Devonian of New York and in a few cases grossly simulating remains from the Wisconsin or Iowa areas were designated "western migrants" commingling with species from the east in a shallow strait opening at the same time to the Atlantic and Pacific. The correlation was thus completed and the "Hamilton" extended to all points of the compass over half a dozen physiographic provinces of North America.

The conception of mid-Devonian paleogeography thus reviewed is, of course, extreme, and individual workers have long known that this

[17] A forthcoming publication by G. A. Cooper, of Yale University, contains the results of a detailed revision of the New York sections.

position was not in accord with actual fact. The past decade has witnessed a careful collection of detailed paleogeographical data, but there has been no attempt to summarize these facts connectively. A brief review of the knowledge of the Middle Devonian of the northern Mississippi Basin has been sketched in a recent paper by the author.[18] It was pointed out that the outcrops of Devonian rocks nearest adjacent the Traverse on the west, those of eastern Wisconsin, were deposited at a considerably later time; and that the Cedar Valley formation, the Devonian of Iowa bearing closest faunal connection with the Milwaukee beds, lies above the " Cuboides zone " in that State, placing it unquestionably in the Upper Devonian.

EVIDENCES FOR PROPER POSITION IN THE GENERAL TIME SCALE

Beds of Traverse age again appear at the surface in northwestern Ohio. These outcrops trend in a general northeast-southwest direction from Lucas to Paulding Counties and have been described in two bulletins of the Geological Survey of Ohio.[19] The Traverse with a slight northwest dip here appears on the surface as the southeastern portion of its broadly concentric outcrop and overlaps to the eastward on the Cincinnati axis. The actual thinning and disappearance of these beds has not been traced, but shortly to the eastward the same stratigraphic position is held by the eastwardly thickening Delaware limestone and its distinctive southern fauna. The greatest thickness of Traverse beds in this region is seen at Ten Mile Creek, a little south of Silica and 10 miles west of Toledo in Lucas County, where the exposed section shows some 47 feet of Traverse delimited below at the contact with the Columbus limestone carrying a true Onondaga fauna. The Traverse apparently thickens westward, but that the complete thickness is in the neighborhood of 50 feet at its westernmost exposure may be seen in the close proximity of the Ohio shale to the west.

The Traverse beds exposed in northwestern Ohio bear a fauna identical with that found in the lower part of the Presque Isle stage farther northward in the vicinity of Alpena in Michigan. Following is a partial list of species common to the Traverse of Ohio and the Bell shale of Michigan.

Heterophrentis prolifica (Billings).
Prismatophyllum cf. *davidsoni* (Edwards and Haime).
Ceratopora near *jacksoni* Grabau.
Cystodictya near *gilberti* (Meek).

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[18] Pohl, E. R. Middle Devonian Pelecypods of Wisconsin and Their Bearing on Correlation. Wash. Acad. Sci., vol. 19, No. 3, pp. 53–59, 1929.
[19] Stauffer, C. L. Geol. Surv. Ohio, ser. 4, Bull. 10, pp. 144–156, 1909. Stewart, G. A. Geol. Surv. Ohio, ser. 4, Bull. 32, 1927.

Fistulipora vesciculata (Hall and Simpson).
Botryllopora cf. *socialis* (Nicholson).
Monotrypella ohioensis Stewart.
Reteporina striata (Hall).
Streblotrypa cf. *hamiltonensis* (Nicholson).
Stropheodonta cf. *demissa* (Conrad).
Leptostrophia cf. *perplana* (Conrad).
Pholidostrophia species cf. *iowensis* (Owen).
Chonetes near *coronatus* (Conrad).
Chonetes fragilis Stewart.
Leiorhynchus lucasi Stewart.
Atrypa reticularis (Linnaeus).
Spirifer near *oweni* Hall (*euryteines* Owen of Stewart).
S. prolificum Stewart.
Grammysia species cf. *nodocostata* Hall.
Pterinea near *flabella* (Conrad) and several varieties.
Phacops milleri Stewart.

The lowest Traverse is thus seen to rest on Onondaga strata and is nowhere known to overlap on younger beds. The basal Traverse is therefore immediately post-Onondaga in age. The basal contact may again be seen in the Alpena region, but since the exact relationships of the Dundee and the overlying "Manitoba beds" are not completely understood direct inferences are best not drawn there.

The Traverse beds thicken to the northward until at their northern edge of outcrop in the northern counties of the Southern Peninsula of Michigan they aggregate between 500 and 700 feet of deposits, mostly highly calcareous. The upper beds of the Thunder Bay stage on the east carry an abundant and very distinctive association of species already cited in part on a preceding page.

Turning now to the Middle Devonian of southwest Ontario a few sections are found exposed on and near the shores of Lake Huron and on the Ausable River and a few of its tributaries in Ontario. These are the famous Canada West localities which have been for a century a paradise of paleontological collectors. Much has been written on the faunas and stratigraphy of the district, and the occurrence has played an important part in former conceptions of Devonian paleogeography, but the full significance of the sections has only recently been learned. Mr. Charles Southworth, of Thedford, an ardent local collector, discovered in 1926 beds representing the lowest exposed portion of the mid-Devonian sequence of the district. These may be seen at times of low-water level in the bed of the Ausable River at Grand Bend on the line between Lambton and Huron Counties. The sequence is carried upward interruptedly to the southward through the "Ipperwash limestone" and the "Olentangy shale," which underlies the "Encrinal limestone" of this section. The exposed succession to the base of the "Encrinal limestone" aggregates close to 60 feet of beds and according to the fossil content is directly correlatable with

the upper portion of the Thunder Bay stage of eastern Michigan. The reference of these beds to the Olentangy shale of Ohio has long been known to be incorrect, and on the grounds here discussed the lower portion of the Ontario section is necessarily considered an eastward extension and integral part of the Thunder Bay stage of the Traverse group. A number of closely differentiated species common to the Thunder Bay stage of Michigan and the lower portion of the Ontario section are cited below.

Cystiphyllum aboreum Grabau (chironym).
Ceratopora cf. *partita* (Winchell).
Cladopora (*Cocnites?*) *fisheri* (Billings).
Trachypora (?) *proboscidialis* (Rominger).
Alveolites subramousus Rominger.
Scalaripora separata Ulrich.
S. approximata Ulrich.
Fistulipora (? *Dichotrypa*) *corrugata* Ulrich.
F. stellifera Ulrich.
Chonetes near *scitula* Hall.
C. near *vicina* (Castelnau).
Pentamerella, new species.
Tentaculites attenuatus Hall (var.)
Spirifer arkonense Shimer and Grabau.
Cyrtina species near *hamiltonensis* Hall.
Cystodictya near *incisurata* (Hall).
Megistocrinus concavus Wachsmuth.

Collections from the lower beds of the Thunder Bay of Ontario are incomplete at present but further additions are certain to bring to light much if not the entire fauna contained in the strata at Partridge Point in Michigan.

Having established the identity of the Thunder Bay strata in Ontario we find them capped by true Hamilton beds overlapping from the New York province. This is the most westward occurrence of beds belonging undeniably to the New York Hamilton, and they fortunately can be placed accurately in the generalized section of that State. The "Encrinal limestone" and the "Coral Bed" of the Widder beds, so classic for their abundant and beautiful fossil remains, are identical with the same beds of the East Bethany section described by Slocum.[20] The occurrence of these strata at the latter locality is found at the long railroad cut a mile and a half west of the station at East Bethany. Slocum, however, in collecting the abundant remains from the talus of this locality mistook the position of the "Coral Bed" to lie below the "Encrinal limestone." Subsequent work at this place has established the fact that the beds under discussion hold the same reference to each other as they do at Arkona and in vicinity of Thedford in Ontario, 200

[20] Slocum, A. W. Field Col. Mus. Publ., vol. 2, pp. 257–265, 1906.

miles farther west. A study of the succession in the region of East Bethany places the age of the two beds named as early Moscow. It is unnecessary here to give a complete faunal list of those species common to the portions of the sequence in Ontario and New York under discussion, for these have been endlessly published elsewhere without results. Suffice it to say that every species found at the one locality may be identified at the other, even to the rarer forms, such as *Pugnax kernahani* Whiteaves and *Eleutherocrinus cassedayi* Shumard and Yandell.

The westward migration by overlap of this portion of Hamilton deposits into Ontario sharply delimits the upper boundary of the Thunder Bay. The conditions of contact indicate a break of considerable duress, and paleogeographical conditions in the upper Mississippi Basin point to a comparatively early cessation of Traverse sedimentation at this location. It is highly probable that Ludlowville and even Skaneateles time are represented here only by the unconformity. This is necessarily so, for it has been shown that the seas of the Traverse were slowly receding to the northward shortly after their first encroachment in Presque Isle time.

The stratigraphic position occupied by the Traverse group is thus clearly delimited, as occurring between the Onondaga and the Hamilton, and the time scale is extended by the interpolation of at least 700 feet of interrupted limestone deposition.

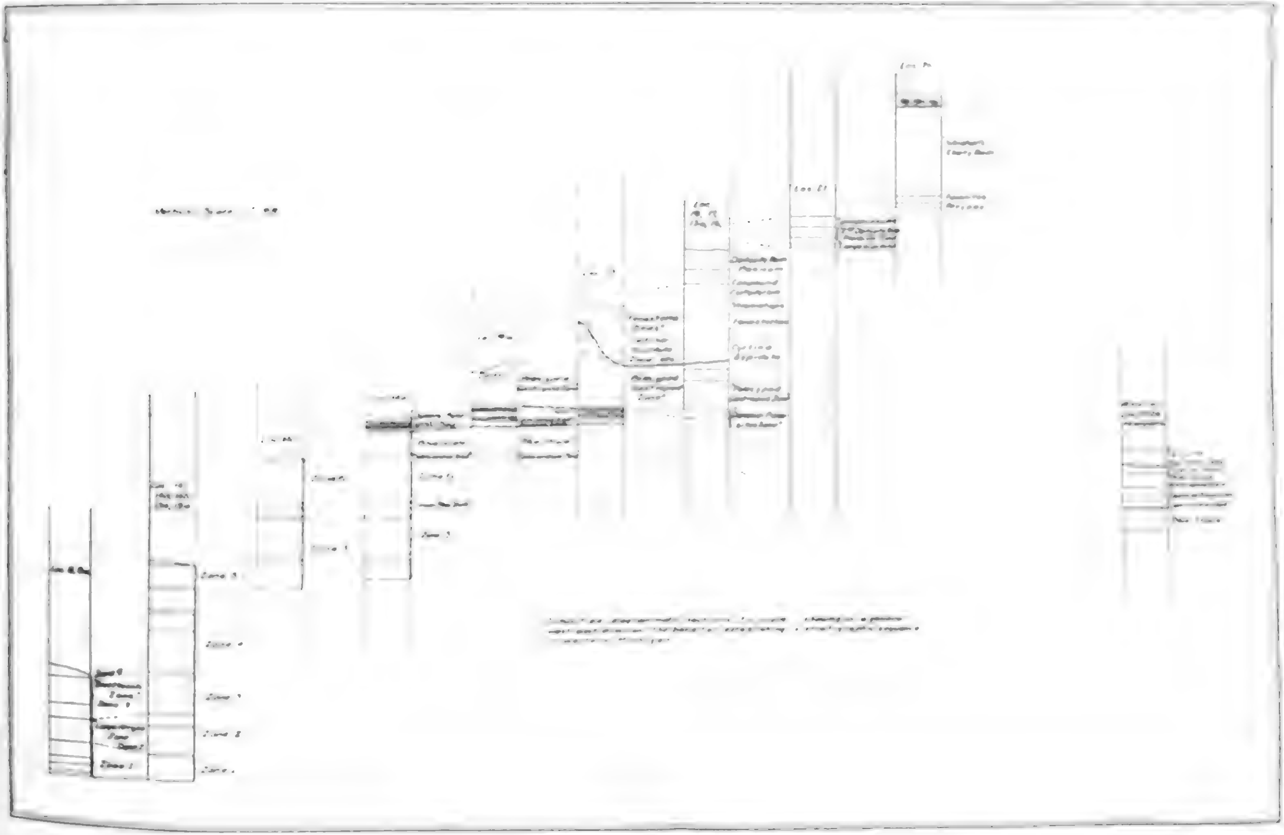
DERIVATION. WHENCE CAME THE TRAVERSE?

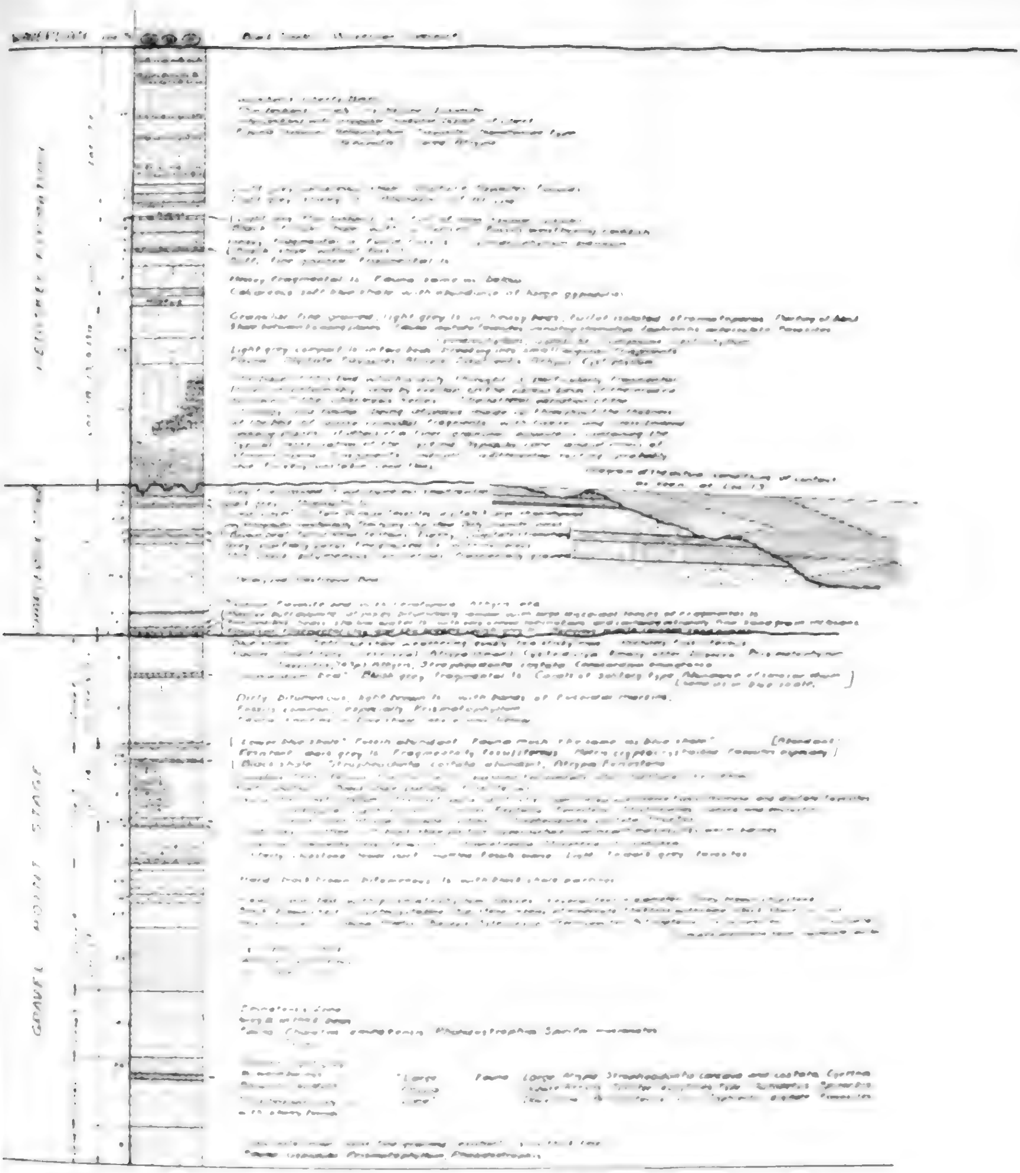
Throughout much of Paleozoic time invasion of North America by epicontinental seas with northern connections was active. Axes and basins had long been moulded in semipermanent trend, and their positions were closely related to the derivation and distribution of mid-Devonian strata in the northern Mississippi Basin. The methods by which paleogeographic conditions are reconstructed are essentially paleontologic, for due to subsequent erosion or burial under later deposits a case where it is possible to trace the overlap of beds upon the barriers is exceptional. To reconstruct the geographic conditions during the deposition of the Traverse beds we may fortunately combine the physical and faunal criteria.

Certainly the Traverse faunas have no close relatives in strata having known southern connections. The Traverse stages are furthermore paleontologically isolated from even the Middle Devonian formations which were deposited in the same general region, which in the case of the Hamilton beds overlap the former. Precise information bearing on Middle Devonian remains found in the Arctic and the northern Canadian Provinces is lacking and specific lists

are far from complete. The generic types are, however, sufficiently well known to indicate the connection of the Traverse forms with a northern origin. This is to be expected, for there is not the slightest possibility of their origin in the south or west and an eastern derivation is denied by stratigraphic conditions. It has further been pointed out that the Traverse strata thin to the southward and overlap to the eastward. Thus we come to the conclusion that the Traverse seas successively advanced from the northward across the Laurentian mass into an irregularly and intermittently sinking basin occupying southwestern Ontario, northwestern Ohio, all of the Southern Peninsula, and the eastern part of the Northern Peninsula of Michigan, and opening by way of James Bay and Hudson Bay to the Arctic and the North Atlantic Oceans.

U.S. GOVERNMENT PRINTING OFFICE: 1929





FOR REFERENCE TO PLATE SEE PAGE 12

NEW GENERA AND SPECIES OF MUSCOID FLIES

By J. M. Aldrich

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The present paper includes descriptions of four new genera and eight new species of muscoid flies; types of all the species are in the National Museum.

Family SARCOPHAGIDAE

Genus JOHNSONIA Coquillett

Johnsonia Coquillett, Proc. Acad. Nat. Sci. Philadelphia, vol. 47, 1895, p. 316.—Williston, Manual, N. A. Dipt., 1908, p. 350.—Aldrich, Sarcophaga and Allies, 1916, p. 30.—Townsend, Revista Mus. Paul., vol. 15, 1926, p. 215.—Enderlein, Arch. f. Klass. u. Phyl. Ent., vol. 1, 1928, p. 45.—Curran, Sci. Surv. Porto Rico and the Virgin Ids., vol. 11, 1928, p. 96.

The type species is *elegans* Johnson. Keys to the species are given by Aldrich and Curran.

JOHNSONIA FRONTALIS, new species

Male.—Differs from *Johnsonia elegans* Coquillett principally in having long pulvilli and much narrower front. It has the same generic characters, consisting mainly of a single pair of orbital bristles; a few small hairs on the parafacials; arista long-plumose more than half way; a single pair of long reclinate verticals; back of head bulging and with only dark hair except just above the neck; and first, third and fifth veins hairy. The abdomen is reddish, subshining. The legs are reddish with a considerable tinge of brown, tarsi black. All the pulvilli elongated, the front ones about as long as the last tarsal joint, which is provided with several uncommonly long hairs projecting out over the pulvilli. Chaetotaxy as in *elegans*.

Length, 6 mm.

Described from one male collected at Miami, Fla., November 18, by C. H. T. Townsend.

Type.—Male, Cat. No. 41812, U.S.N.M.

GLUTOXYS, new genus

Hypopleurals present; postscutellum wanting; eyes bare; arista long plumose for about two-thirds of its length; third antennal joint long, reaching the vibrissae, which are at the oral margin; antennal axis a little longer than vibrissal; parafacials bare, narrow; facial ridges very flat; front narrow, with a single row of frontals, all somewhat reclinate, reaching to base of antennae; palpi rather small; proboscis fleshy, short. First vein bare, fourth with broadly rounded bend ending exactly in apex; first posterior cell open. Second and third abdominal segments with discals.

Genotype.—*Glutoxys elegans*, new species.

GLUTOXYS ELEGANS, new species

Male.—Head and abdomen black; thorax yellow; front at narrowest near middle 0.17 of head width; outer verticals not developed; ocellars very minute; parafrontals silvery, a little wider than median stripe; antennae blackish, third joint nearly three times the second; cheek almost bare, about one-sixth of eye height; palpi dark yellow. Thorax wholly yellow in ground color, including metanotum; viewed from behind with a very distinct silvery band just in front of suture, extending down the side to cover the sternopleura and middle coxa; also with thin silvery pollen extending across the thorax just in front of the scutellum. Chaetotaxy: dorsocentral 3, 3; acrostichal several pairs hair-like, one larger anterior and a prescutellar a little larger; humeral 2; presutural 1; notopleural 2; supraalar 2, (posterior large); intraalar 0; sternopleural 2; pteropleural 0; hypopleurals about 4.

Abdomen rather slender, narrow and pointed posteriorly, black in ground color with broad basal silvery bands covering anterior half of second and third segments; fourth segment mostly silvery; first segment with marginal row, smaller along the middle; second with marginal row of six widely separated; third with marginal row of eight; fourth with apical row of about eight and a single pair of discals as in the second and third. Genitalia small.

Legs black, the coxae and basal half or more of all femora yellow. Claws and pulvilli only a little enlarged; middle tibia with one smallish bristle on outer side; hind tibia with only one outer and one inner on the hind side and one on the outer front.

Wings yellowish with a faint dark mark extending from base of third vein forward to costa; third vein with three or four bristles at base; first vein ending directly in front of small cross vein; apical cell open in tip of wing; hind cross vein slightly longer than last section of fifth vein, joining fourth almost in the middle between anterior cross vein and bend.

Length, 4.2 mm.

Described from seven males collected in Santo Domingo, West Indies, July 5–8, by August Busck.

Type.—Male, Cat. No. 41813, U.S.N.M.

Family TACHINIDAE

Genus PHOROCERA Robineau-Desvoidy

Phorocera ROBINEAU-DESVOIDY, Myodaires, 1830, p. 131; Dipt. Environs de Paris, 1863, vol. 1, p. 509.—ALDRICH and WEBBER, Proc. U. S. Nat. Mus., vol. 63, art. 17, 1924, p. 43.

The genotype is *Tachina assimilis* Fallen. Aldrich and Webber have discussed the synonymy in detail.

PHOROCERA RUSTI, new species

Male.—A rather large gray species with heavily striped thorax; the head (except vertex and occiput), and the fourth abdominal segment with deep golden pollen. Front rather wide, at vertex 0.25 of head width. The vertex with gray pollen, which extends as far as the second of the large recurved frontals, where it changes into the dense golden pollen which continues down around the eye and narrowly on the posterior orbit; below the reclinate frontals the much smaller decussate ones are rather scattered but become normally large at the antennae, the lowest ones fully meeting the row of large bristles on the facial ridges. The parafrontal at the second reclinate bristle is slightly wider than the seal-brown middle stripe and much wider near the antennae. Cheek about one-third the eye height, sloping upward anteriorly. Vibrissae at oral margin but considerably above lower edge of head. Antennae black, rather slender, third joint three times the second; arista slender, thickened only on basal fourth. Palpi black. Thorax gray with four very distinct black stripes, the two median extending some distance behind the suture, the outer almost to the scutellum. Acrostichal 3, 3; dorsocentral 3, 3; presutural 2; sternopleural 2, 1; scutellum with three pairs of laterals, apical pair decussate and depressed, more than one-half as long as the longest lateral, a large pair of discals; ground color of scutellum distinctly yellowish. Calypters waxy-white, with white rim. Abdomen with thin pollen, somewhat tessellated, so that irregular patches appear to be shining; fourth segment with very striking dense yellow pollen and yellow ground color; first segment with a very small pair of median marginal bristles; second with a large pair; third with a marginal row slightly interrupted next to the middle pair; fourth segment with an irregular row of discals and a few small apical. Genital segments yellow, very small, the forceps brown, the inner ones close together and rather strongly curved

forward and rather blunt; the outer forceps a little shorter and wider, the front edge slightly concave and the tip a little more acute. Legs black; tibiae brown, middle tibia with two or three bristles on the outer front side; hind tibia with a row of cilia mixed with several larger bristles. Claws and pulvilli large, the latter grayish. Wing subhyaline with slight brownish tinge along the veins, bend of fourth vein almost rectangular but a little rounded, last section slightly concave; third vein with only two or three hairs at base.

Female.—Vertex 0.29 of the head width, the pollen gray to the second reclinate bristle, changing as in the male to a very deep golden color, almost orange; the two orbital bristles are rather far apart and the parafrontals have fewer and smaller hairs than usual. There is a changeable dark spot in the pollen at the level of the lowest frontals. Abdomen rather more uniformly pollinose than in the male, still with slight tessellation. Middle tibia with one large, and above it one small bristle on outer front side. Wing hyaline.

Length, male, 9.3 mm.; female, 8.8 mm.

Described from one male and two females; the former was collected at Tucuman, Argentina, by E. W. Rust, on March 16, 1917, while he was connected with the agricultural experiment station; it bears the label "Est. Exp. A. C. No. 233." The females, one of which is the allotype, were reared at the same place in February, 1929, by Harold E. Box, from cutworms, *Remigia repanda;* both of these have the puparia with them, and one is returned to Mr. Box.

Type and allotype.—Male and female, Cat. No. 41896, U.S.N.M.

The species agree with the characters of the subgenus *Neopales* Coquillett.

Genus GAEDIOPSIS Brauer and Bergenstamm

Gaediopsis BRAUER and BERGENSTAMM. Zweifl. Kais. Mus., pt. 5, 1891, p. 336; pt. 6, 1893, p. 190.—COQUILLETT, Revis. Tachin., 1897, p. 136.—THOMPSON, Canad. Ent., vol. 43, 1911, p. 315.—ADAMS, in Williston's Manual N. Amer. Dipt., 1908, p. 376.

Poliophrys TOWNSEND, Taxonomy Musc. Flies, 1908, p. 90.

Eugaediopsis TOWNSEND, Proc. U. S. Nat. Mus., vol. 49, 1915, p. 620.

Eugaedia TOWNSEND, Proc. U. S. Nat. Mus., vol. 49, 1915, p. 621.

The type species of *Gaediopsis* is *mexicana* Brauer and Bergenstamm; that of *Poliophrys* is *sierricola* Townsend; that of *Eugaediopsis* is *Gaediopsis ocellaris* Coquillett; and that of *Eugaedia* is *Gaediopsis setosa* Coquillett.

GAEDIOPSIS RUFESCENS, new species

Male.—Ocellar bristles absent, front moderately prominent, the antennal axis slightly longer than the vibrissal; facial ridges with long bristles extending almost up to the arista; parafacials with small hairs on the outer half and an irregular row of small bristles

extending up the middle, the inner half bare. Vibrissae slightly above the oral margin, which is rather strongly protuberant. Eyes hairy; cheek nearly half the eye height. Palpi yellow, of ordinary size; proboscis short; both pairs of verticals developed; front with rather dense erect dark hair. Ground color of head pale brownish, with thin whitish pollen on the face and around the posterior orbit, in some lights extending on the cheeks and up the anterior orbit nearly to the vertex. Most of the parafrontal area shining translucent brownish in color. Antennae reaching almost to the vibrissae, third joint rather slender, two and one-half times the second. Second aristal joint several times as long as wide, about one-fifth as long as the last joint; the thickening of the arista extending almost to its middle, but not very striking. The basal joints of the antennae dark brown, third joint black.

Thorax reddish brown with the dorsum black except in front of the scutellum, above the wing, and around the humerus, where it is more brownish. Pleura brown anteriorly; lower part of sternopleura, most of the pteropleura, and posterior part blackish. Scutellum reddish brown, with four pairs of marginal bristles, the middle or apical ones nearly as large as the others, slightly decussate. Sternopleural 4; posterior dorsocentral 4; acrostichal 3, 3.

Abdomen rather broad, with dense erect coarse hair; ground color mostly reddish brown, black immediately behind the scutellum to the end of the second segment; first and second segments with a single pair of marginal bristles, third with a marginal row, fourth with a somewhat irregular row before the middle and another about the posterior two-thirds. Genitalia small and concealed.

Legs including coxae reddish brown, with all the pulvilli and claws decidedly enlarged. Middle tibia on outer front side with four bristles before middle, increasing in size, the first quite small. Hind legs absent.

Wings considerably infuscated on the anterior basal part, the dark color following the veins throughout, noticeably on the anterior cross vein. Hind cross vein almost parallel with wing margin; fourth vein with rounded rectangular bend, thence slightly concave to margin. Third vein with two or three setules at base. Calypters white, the hind ones translucent.

Female.—The single female is somewhat paler than the male, but the mesonotum shows four distinct blackish stripes and a somewhat connected transverse blackish band behind the suture. Eyes very distinctly pilose. Abdomen with more scattered pile, which is not so coarse and erect as in the male. The third segment in some lights shows tessellated thin pale pollen as far as the marginal row of bristles.

Length, male, 9.5 mm.; female, 8 mm.

Described from one male and one female; the male was collected at La Suiza, Costa Rica, March 8, by Pablo Schild, and is from Professor Melander's collection. The female was collected at Amecameca, Mexico, September, 1900, by O. W. Barrett.

Type.—Male, Cat. No. 41810, U.S.N.M.

The species agrees exactly with the generic characters of *Gaediopsis*, except in the absence of the ocellar bristles. In this respect it agrees with *Eugaediopsis* Townsend (type *ocellaris* Coquillett). At present I am inclined to regard the absence of ocellar bristles as not a sufficient character to establish a genus.

Genus EUANTHA Van der Wulp

Euantha Van der Wulp, Tijsch. v. Ent., vol. 28, 1885, p. 198; Biologia, Dipt., vol. 2, 1891, p. 248.—Brauer and Bergenstamm, Zweifl. Kais. Mus., pt. 4, 1889, p. 137; pt. 6, 1893, p. 128.—Townsend, Annals and Mag. Nat. Hist., vol. 19, 1897, p. 34.—Adams, in Williston's Manual N. A. Dipt., 1908, p. 356.—Aldrich, Proc. U. S. Nat. Mus., vol. 72, art. 7, 1927, p. 28.

The type species is *Dexia liturata* Olivier. Townsend[1] has written that *Euantha* is a synonym of *Sophia* Robineau Desvoidy,[2] but there are great discrepancies between his descriptions and the species of *Euantha*, so I can hardly believe that the genera are the same. A key to the species has been published by me.

EUANTHA FLAVA, new species

Female.—Wholly yellow except the tarsi, which are black, and the tip and hind margin of wing, which are infuscated. The single specimen has been considerably damaged, the lower part of the head pressed in. The front, as in females of the type species, is shining on both sides of the narrow frontal stripe, but has a narrow pollinose yellow orbit. Third antennal joint a little longer than second, the arista with erect plumosity; vibrissae large; only one pair of vertical bristles; ocellars minute, or perhaps wanting; frontals about six, barely reaching to base of antennae; back of head shining, with yellow hair; only a few coarser black hairs above. Thoracic chaetotaxy: Dorsocentral 3, 3; acrostichal 0, 0; humeral 2, presutural 1, notopleural 2; mesopleural with only 1 posteriorly; sternopleural 1; hypopleural 1; supraalar 2; intraalar 1; postalar 2; scutellum with 2 lateral, 1 apical, of good size and decussate, no discal. Postscutellum distinct but not large. Calypters very small.

Abdomen fusiform, considerably narrowed at base, one and one-half times as long as thorax, composed of five evident segments, the basal one more distinct than usual. The first of the larger segments has a pair of large median marginals and three lateral in a diagonal

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[1] Revista Mus. Paul., vol. 15, 1926, p. 218.

[2] Myodaires, 1830, p. 317.

row; the second has one pair of discal, one pair of median marginal and one lateral; the third has one discal and an encircling marginal row of 12; the fourth has one discal and a marginal row of 10.

Legs moderately slender, the front tarsi distinctly compressed, deep black, and about one-fourth longer than the tibiae. Middle tibia with one bristle on the outer front side, two smaller on the outer hind side, and one flexor; its tarsi are black, not enlarged, and as long as the tibia. Hind femur with five bristles on the upper anterior side, two on the lower posterior; hind tibia with three bristles on inner hind side, three on the outer hind, and two on the outer front side; the tarsi deep black and a little shorter than the tibiae.

Wing large, rather narrowed toward the base, the venation almost as in *liturata*, but the bend of the fourth vein without appendage. The first posterior cell has the same comparatively wide opening a little before the tip of the wing. There is a small but distinct costal spine; the apical third of the wing is infuscated, more intensely on the apical part, and a broad dark shadow follows the fifth vein almost from the base to its apex, where it blends with the apical infuscation. The basal two-thirds of the wing, except behind, is dark yellow; the first vein is bare and the third has only one or two minute hairs at the base.

Length, 10 mm.

Described from one specimen, Couchamayo, East Peru (Rosenberg).

Type.—Female, Cat. No. 41811, U.S.N.M.

On account of the condition of the specimen some of the chaetotaxy may be incorrect and it is possible that in a well-preserved specimen the calypters would be larger, in other words they may be partially broken off. There would seem to be plenty of characters for a new genus allied to *Euantha*, but it would be advisable to await the examination of a good specimen before establishing such a genus. There is no question that *Euantha* is a closely allied genus.

CALLOTROXIS, new genus

Male only. Dexiid-looking flies of about the build of the common Ptilodexias of the United States, but differing mainly in having pilose eyes, short proboscis, and vibrissae at level of mouth.

Postscutellum and hypopleural bristles present. Antennal axis of head equal to vibrissal. Outer vertical only as the last of the postorbital series of rather long and slender hairs; ocellars only a cluster of hairs; frontals beginning a little before ocellar triangle, none reclinate, about 10 in all, the lowest hardly reaching base of antennae;

parafacials bare, wide, about half as wide as cypleus, which is flat, a little projecting below, and with a mere trace of a carina above; cheek fully equal to half the eye height; facial ridge with a few coarse hairs above vibrissae; palpi normal, proboscis short, the portion beyond the elbow hardly longer than height of cheek; third antennal joint about twice the second, arista pubescent, the basal joints short. Anterior acrostichals well developed; discal abdominal present. Bend of fourth vein a little angular, first posterior cell more widely open than usual, distinctly before the wing tip.

Genotype.—*Callotroxis edwardsi*, new species.

CALLOTROXIS EDWARDSI, new species

Male.—Front at narrowest part 0.19 of head width; head with dense cinereous pollen on parafrontals, parafacials, clypeus and orbit; the cheek broadly reddish in front; palpi red or brownish, tips darker; antennae black, base of third joint red; beard mostly dark.

Dorsum of thorax with rather striking white pollen forming a broad margin on each side, the central part shining black but somewhat dissected by indistinct and varying white pollen. When viewed from in front two stripes of pale pollen within the dorsocentral rows extend to the suture and begin again some distance behind and extend to the scutellum. In some angles these marks tend to disappear, the general effect being of a large blackish central spot on mesonotum. Scutellum red with thin white pollen. Chaetotaxy: Acrostichal 3, 3; dorsocentral 3, 3–4; humeral 4; notopleural 2 (with a few long hairs); posthumeral 1; presutural 1; supraalar 3; intraalar 3; postalar 2; sternopleural 2, 1; scutellum with two lateral and an equally long apical slightly decussate and a small hair-like pair of discals.

Abdomen rather slender, black in ground color, with a conspicuous large elongate reddish spot on each side occupying most of the first to third segments so that the intermediate black portion decreases in width and may almost disappear on the third segment; first segment with a pair of median marginal bristles; second segment with a pair of median marginals and three pairs of discals, one before the other, and mixed with numerous very erect bristly hairs, which do not occur except on the middle region; third segment with the same kind of discals and bristly hairs but with a marginal row of about ten; fourth segment with bristles and erect bristly hairs over the whole dorsal surface; the fifth segment (a narrow intermediate space preceding the two genital segments) densely covered with erect small bristles, rather striking. The red portion is covered with rather brilliant white pollen matching that on the thorax so that the pattern is quite striking; fourth segment more or less

infuscated; genitalia mostly reddish in color, of about the same type as in *Ptilodexia*, the outer forceps being flat and broad, but in this case slightly curved forward to an acute tip; the inner forceps are straight, very slender, and so close together that in one specimen they appear to be united.

Legs black; all the pulvilli large and dark colored; middle tibia with one bristle on outer front side; hind tibia with five or six bristles on outer side, ending a little beyond the middle. Calypters white.

Wings subhyaline; third vein with only four or five hairs at base; hind cross vein oblique and sinuous, joining the fourth vein only a little before the bend; last section of fifth vein less than half the hind cross vein.

Length, 10.5 mm.

Described from two males. The type was received from Prof. D. S. Bullock, Angol, Chile, who reared it October 29, 1928, "from roots of basket willow"; the paratype was collected at Conception, Chile, December 26–28, 1926, by F. Edwards and M. Edwards, after whom the species is named; it was collected by a British Museum expedition and the specimen is returned to that institution.

Type.—Cat. No. 41651, U.S.N.M.

This species bears a striking resemblance in its brilliant pollinose pattern to *Huascarodexia pulchra* Townsend [3] described from a single female specimen collected in Peru. Townsend's species, (female, male unknown), has the arista short plumose, the third antennal joint considerably longer, parafacials much wider, well-developed proclinate ocellars, proboscis somewhat longer, and the abdomen with very feebly developed discals. Both genera have pilose eyes, an unusual character in species so distinctly dexiine.

CARTOCOMETES, new genus

Eyes bare; front prominent, broad in both sexes; third antennal joint twice the second, reaching nearly to vibrissae, which are far apart at oral margin; second aristal joint a little elongate, about one-sixth of the third; ocellars large, proclinate and divergent; frontal bristles reaching to middle of second antennal joint; proclinate orbitals present in both sexes; parafacials with numerous quite long hairs; face a little concave, the ridges low, with three or four bristles above the vibrissae, not reaching middle of the face; cheek about two-fifths eye height; palpi and proboscis normal; antennal axis almost double the vibrissal. Postscutellum and hypopleural bristles present. First posterior cell open in apex of wing; the fourth vein with broadly rounded curve; first vein bare; third with sparse, long,

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[3] Ins. Ins. Menst., vol. 6, 1918, p. 176.

erect hairs. Abdomen broad; discals on abdominal segments; outer side of all tibiae in female with numerous long slender bristles, less abundant in male.

Genotype.—Cartocometes io, new species.

CARTOCOMETES IO, new species

Female.—Front wide, 0.45 of head width, the frontal stripe occupying about one-half of this, rather light red in color; lower part of head yellowish red, antennae of the same color; frontal bristles six, the uppermost not appreciably reclinate; the usual two orbital bristles present; parafacials with numerous black hairs; back of head with some small pale hairs on the lower part not very conspicuous; palpi yellow.

Thorax black on the disk, broadly reddish yellow on the sides and pleurae, the latter, however, somewhat mottled with black behind. Chaetotaxy: acrostichal 3, 3 (the hindmost rather large); dorsocentral 2, 3; humeral 4; presutural 2; notopleural 2; supraalar 1; intraalar 4; 2 between supraalar and intraalar; postalar 2 (the inner much larger); sternopleural 2, 1; pteropleural 1 small; scutellum with 3 lateral pairs and a rather large decussate apical, discal poorly developed, postscutellum well developed, black like the remainder of the metanotum, the scutellum being reddish yellow. Calypters white, the rim slightly infuscated on the inner side.

Abdomen rather flat, hind edges of all the segments faintly reddish, the surface somewhat variably mottled with light and dark pollen. First segment rather long with a marginal pair, and in one specimen a single discal; second segment with a discal pair, and a marginal row of about 14; third with two pairs of irregular discals and several hair-like bristles scattered over the surface without regular order, hind margin without a distinct row; fourth segment with irregular erect scattered hair-like bristles beginning at the front edge, no distinct marginal row. The sides of the abdominal segments have some irregularly arranged long bristles.

Legs, including tarsi, yellow, the femora with traces of infuscation; all the tibiae with strikingly long hair-like bristles arranged in several irregular rows; tarsi rather strikingly short, pale to the tip.

Wings subhyaline, the hind cross vein erect, joining fourth vein hardly beyond the middle between small cross vein and bend, the latter very broadly rounded; the erect coarse hairs of the third vein large, extending far beyond the cross vein in one specimen but only to it in the other.

Length, 5 mm.

Male.—Front at vertex 0.43 of head width, more prominent than in female; femora black in ground color except broadly on underside apically; claws and pulvilli small. Genitalia of unique struc-

ture; the inner forceps forming a short heart- shaped pad like structure covered with dense hairs, the notch being next the anus and the tip very blunt; the outer forceps long and slender, shining black, curving toward each other at tip; penis upright and blunt, the back black, the front with white swelling on basal half and the apex with narrow white collar.

Described from one male and five female specimens. The type, female, is from Riverhead, N. Y., collected May 3, 1927, by H. C. Huckett. The allotype male and one paratype female were reared at Newbury, Vt., from *Malacosoma disstria* on April 24–29, 1925 (Gip. Moth Lab. No. 10081K6); one female from the same host at Dedham, Mass., May 4, 1916 (G. M. L. No. 10001C18); another from the same host at Bradford, Vt., April 27, 1925 (G. M. L. No. 10081K6a); and another from *Malacosoma americanum* at Melrose Highlands, Mass., May 11, 1916 (G. M. L. No. 10000i).

Type.—Female, Cat. No. 41814, U.S.N.M.

The female of the species differs from all others known to me in the numerous long hair like bristles occurring on all the tibiae; the only species approaching it is *Metopomuscopteryx tibialis* Coquillett, which differs in several important characters. The nearest relative I can discover is *Chromatocera setigena* Coquillett, which, however, has ordinary tibiae, hairy eyes, the fourth vein with rectangular bend and ending considerably before the tip.

TROPHOMYIA, new genus

Allied to Tachina, agreeing with the genotype (*grossa* Linnaeus), in being large and robust, with stout but not very numerous spines; parafacials hairy, vibrissae above oral margin; second antennal joint longer than third; vibrissal axis equal to antennal; postalar callosites with tuft of bristles which blend with a depressed marginal row on scutellum; and in many details. It differs from *grossa* in having the face flat, the oral margin not projecting, the facial ridges more bowed outward, strongly converging below, bristles of thoracic disk much reduced except at sides and behind, etc.

Eyes bare; second joint of arista elongated, third bare; ocellar bristles absent or small and proclinate; palpi normal, proboscis short, no discal bristles on abdomen except last segment; second to fourth sternites with a group of stout spines, none on inflexed ends of tergites; prosternum bare.

Genotype.—*Trophomyia pictipennis*, new species.

TROPHOMYIA PICTIPENNIS, new species

Male.—Front 0.28 of head width at vertex, thence widening rapidly; head wholly deep golden pollinose, the frontal stripe more reddish; parafacials with thin yellow to blackish pile; antennae reddish

yellow, third joint usually infuscated apically, a little more than half as long as second; palpi yellow, with dense short black hair; outer vertical small; one reclinate frontal above, two to four proclinate orbitals; lower frontals broadly diverging, extending as low as base of second antennal joint; upper frontals small and sparse; facial ridges flat, with two or three small bristles next to vibrissae, extending almost laterally; cheek about equal to eye height; the space inclosed by the suture approaches a circle in form, and the parafacial is equal in width to about one-third of its diameter. Back of head with dense deep golden ruff. Thorax black, subshining, pollinose only a little on front edge, humeri and adjacent parts deep reddish in ground color; calypters golden, the hind one bare. Scutellum with about five pairs of bristles on margin, the middle pair smaller and variable; sternopleural 2, 1. Abdomen dark reddish brown to almost black, shining; second and third segments with a little very thin pollen on sides at base, fourth with large lateral basal spots of silvery pollen, not very dense. First segment without marginals, second with a widely spaced upright spiny pair, third with marginal row of a dozen or more, fourth from the middle with numerous spiny bristles; sternites as described. Genital segments small, brownish red.

Legs black, shining, rather stout, the tarsi quite short, pulvilli yellow, conspicuous but not remarkably long; middle tibia with several bristles on outer front side, hind ones a little bowed, with dense cilia irregularly arranged on hind side.

Wings strikingly marked, yellow to the small cross vein, the remainder dark brown along the costa, fading to a slight infuscation behind, the brown however continuing along the veins; fourth vein rectangular at bend, then concave, ending far before tip of wing; third vein with a few hairs at base.

Female.—Front 0.28 of head width at vertex; third antennal joint less than half the second; abdomen wholly shining; pulvilli a little smaller.

Length, male, 16; female, 17.5 mm.

Described from seven males and two females; the males were received through J. R. Malloch from the Federated Malay States Museum, and were collected by H. M. Pendlebury at Selangor, Bukit Kutu, Federated Malay States, altitude 3,500 feet. The females were received from the Vienna Natural History Museum, and are labeled "Rio Demerara, Heyne." They are old specimens; I had described the species from them as South American, when Mr. Malloch saw them and told me he had received the same species from the Orient. On bringing the two lots together it was apparent that the locality label on the females must be erroneous.

The species has a striking superficial resemblance, especially in the color of the wings, to *Nemoraea tropidobothra* Brauer and Bergenstamm, also oriental, which however is a true *Nemoraea* in having the hind calypters pilose above, a very unusual Tachinid character. Another species which must be very similar is *Oxyrutilia jacobsoni* Townsend [4] described from a single female collected at Sumatra. It is said to have a large facial carina and apparently can not be congeneric with the present species.

One male, and one female, type and allotype, are retained, the paratypes returned to the museums from which they came.

Type.—Male, Cat. No. 40979, U.S.N.M.

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[4] Supplementa Ent., vol. 14, 1926, p. 31.

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OÖLITES OR CAVE PEARLS IN THE CARLSBAD CAVERNS

By Frank L. Hess[1]

Custodian of Rare Metals and Rare Earths, United States National Museum

In 1925 Dr. Willis T. Lee, of the United States Geological Survey, collected a considerable number of oölites from Carlsbad, N. Mex. They included little round balls of considerable range in size, to which he gave the somewhat fanciful name of "cave pearls." They were found in small, round, shallow pools, and some resembled eggs in a bird's nest (figs. 1 and 2, pl. 1); others looked like a quantity of stone shot. Still others of the oölites were irregular in shape, and were as much as 2 inches (50 mm.) long, and less thick. So far as known to me, this is the first time that oölites have been found in a cave, though they are common in other places. Excellent examples are on exhibition in the United States National Museum, and their study throws an excellent light on the formation of oölites in general.

By "oölite" is ordinarily meant a tiny, more or less rounded concretion formed of concentric layers of mineral matter. When these are massed together they resemble fish roe—hence the name "oölite," from the Greek *oön*, meaning egg.

The oölites collected by Mr. Lee range in diameter from one-sixteenth of an inch (1.5 mm.) to a little more than an inch (25 to 30 mm.). Most of them are round, some are oval, and some irregular in shape. Their surfaces vary as much as their forms. Some are beautifully polished and opaque, and others, particularly the smaller, are smooth and translucent, resembling little balls of artificially polished onyx. (See pl. 1, fig. 1.) Some have the texture of bisque, others are much rougher. Though most are white, others have a slight yellowish tint or may be clouded with yellow.

[1] Since this article was written I have found a description of irregular, smaller oölites which were discovered in a Swedish mine. (Erdmann, Edv. Stalagmit och pisolitartade bildningar i Höganäs stenokolsgrufa, Shone. Geol. Fören Förhandl., Stockholm, vol. 24, 1902, pp. 501–507, 5 pho. reps.) The illustrations show well the formation of irregular pisolites by dripping calcium carbonate ($CaCO_3$) bearing water (H_2O).

Their inner structure in general is similar, though differing in detail. Sections were prepared for microscopic study of three round oölites, each a little more than half an inch in diameter. These are shown magnified 4⅓ diameters in Plate 2. In each oölite there may be observed a nuclear mass surrounded by a broader noticeably radial zone of more coarsely crystalline material surrounded by circumferential rings of very fine texture. The rings differ in number, thickness, and continuity in the three specimens.

The coarser part of the oölites is certainly calcite, and not aragonite, as might be supposed. The dense rings are apparently also calcite, though their mineral composition is difficult to determine.

The nuclei, too, are all floccules of calcite—aggregates that formed within the little pools as these became supersaturated with calcium carbonate. Drops collecting on the ends of the stalactites above pools begin to lose carbon dioxide, and as they drip and splash into the pool lose enough more to become supersaturated with calcium carbonate, and thus to set free molecules, which begin a separate existence. These molecules attaching themselves to other molecules in the little eddies of a tiny pool form a spherical body. They must have been kept in sufficient motion to maintain this form as they increased in size. The movement of the water caused by the splash of falling drops was probably sufficient. In much the same way oölitic sands have formed on the bottom of Great Salt Lake near the shore, though the grains are very much smaller than the smallest collected in Carlsbad Caverns and average only about one one-hundredth of an inch (0.4 mm.) in diameter. (See pl. 3.) The streams that flow from the great limestone beds of the Wasatch Mountains carry large quantities of calcium carbonate in solution to the lake. Here calcite is precipitated from the supersaturated waters as it is in the tiny pools of Carlsbad Cavern, but in many of the oölites tiny grains of sand form the nuclei. As the lake waters move over the bottom, calcium carbonate is added to the oölites already formed or new ones are started. The size of the oölites is probably closely related to the amount of their movement after they are formed.

Similarly the great oölitic limestone beds of the world have been formed. They are of many geologic ages and are very widely distributed. In this country the oölitic limestone quarried at Bedford, Ind., is one of our best-known building stones and is shipped to all parts of the United States.

Oölites are formed from supersaturated solutions other than those containing calcium carbonate. The great phosphate deposits of Utah, Idaho, Wyoming, and Montana contain abundant oölites of phosphorite—a calcium phosphate containing more or less fluorine

and chlorine. A specimen of phosphate rock from Idaho is shown in Plate 4. Some deposits of iron carbonate have perhaps been laid down in the same way and later recrystallized, so that their oölitic structure is indistinct. The great beds of oölitic iron ores probably have been precipitated in a similar manner. In at least three small crater lakes of Japan, where the water is agitated by sulphurous gases, oölites of sulphur are formed, and in one of them in great enough quantity to be profitably exploited.[2]

Nor is the formation of oölites confined to solutions in liquids. Precipitation of a substance from any moving fluid, such as air or other gases, may produce solids of the same type. In the Mond process of obtaining nickel from its ores the nickel is converted to nickel carbonyl, a gas, and advantage is taken of the principle that substances precipitating in an agitated fluid may be collected as oölites. The gas is run into a reductor and heated somewhat above its decomposition point. Fine granules of nickel are rolled through the decomposing gas and as the nickel separates from the gas it collects on the granules, and thus, metallic balls, true nickel oölites, are formed. (See pl. 5.) Thousands of tons of nickel are annually obtained by this process.

Hailstones are probably formed according to the same principle. A number of snowflakes are matted together by swirling air, or a group of other ice molecules are collected together, and on the mass as a nucleus ice is deposited directly from gaseous water in an atmosphere below the freezing point, making concentric shells very similar in their structure to calcite oölites till hail finally falls as the familiar enemy of crops and greenhouses. Cross sections of large hailstones are very similar to the cross sections of oölites from Carlsbad Caverns, shown in Plates 6 and 7.[3] Oölites of calcite are formed in boiling sugar refinery refuse in the process of making by-product alcohol. They are formed rapidly and are fairly large, 1½ inches or more in longest diameter. Those seen are of coarse texture and do not have smooth surfaces.

The dense and the more visibly crystalline layers or shells in the oölites from Carlsbad Caverns have evidently formed under different conditions and the dense polished layers are probably formed by slow, steady accretion.

Some of the oölites from Carlsbad Caverns are elongated or otherwise vary from a spherical form. (See pls. 7 and 8.) Their form is largely determined by that of the nucleus. An elongated oölite, shown in polished section in Plate 5, Figure 1, tells its own story.

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[2] Oinouye, Y., A peculiar process of sulphur deposition, Journal of Geology, vol. 24, 1916, pp. 806–808.

[3] A good illustration of hailstones showing concentric structure and radial crystallization is given in "Lehrbuch der Meteorologie," by Jul. von Hann, Leipzig, 1915, pl. 25, opposite page 708.

The nucleus here was a fragment of a small stalactite. In the same way many of the oölites of phosphate contain a small tooth or some other fragment as a nucleus. (Pl. 4.) Other elongated oölites in process of formation are shown in Plates 7 and 8.

The rough surfaces on some of the oölites are probably due to a partial drying up of the pools, when the calcite was deposited from a film of water, as on the stalactites. Such oölites soon become attached to the floor. Likewise whenever the drip of the water becomes too small to move the oölites with its splash, or whenever the oölites grow too large to be moved by the splash of the drip that formed them, they also become attached to the bottom, and gradually lose their individual form, coalesce, and form a lumpy floor. Even on the round oölites, which were presumably formed under conditions most favorable for symmetrical growth, deposition did not take place quite uniformly over the whole surface (see pl. 2) and probably means that the asymmetrical deposition took place while the nuclei were quiescent.

Efforts have been made to show that oölites are formed as the result of microbic or other unusual influences, but the oölites of nickel and of sulphur, hailstones, and oölites formed in boiling sugar refuse seem to make it unnecessary to assume other causes for their formation than moving supersaturated fluids. We may wonder why oölites are not formed in more places where limestones of different kinds are deposited, but most limestones are formed, not by precipitation from solution, but through the accumulation of definite preexisting particles. Some limestones, like the Indiana rock, show a combination of the two processes. The nonoölitic limestones, which have been deposited from solution, have probably formed where there has been insufficient motion or insufficient depth of water to make oölites.

EXPLANATION OF PLATES

PLATE 1

FIG. 1. Oölites or cave pearls from the Rookery in Carlsbad Cavern, New Mexico. These sometimes have a surface resembling ground glass and sometimes smooth as if polished.

2. A so-called bird's nest, a shallow depression with pearls like eggs in a nest.

PLATE 2

Sections through the centers of three spherical oölites; note variation in bands of growth.

PLATE 3

Sections of oölitic sand from Great Salt Lake, Utah. Streams from the mountain bring calcium carbonate in solution which is precipitated in the lake. Small particles of sand often form the nuclei of the oölites.

Plate 4

Section of a phosphate rock from Wyoming, showing oölitic structures. In one instance a fish tooth forms the nucleus of an oölite.

Plate 5

Figs. 1 and 2. Elongated oölites from the Rookery. The one at the right sliced and showing a nucleus of a broken stalactite.

3. Section of an oölite of nickel formed by accretion from decomposing nickel carbonyl.

Plate 6

Fig. 1. Hailstones showing concentric structure.

2. Oölite from cave showing a similar concentric structure.

Plates 7 and 8

Oölites of varying shapes formed under varying conditions.

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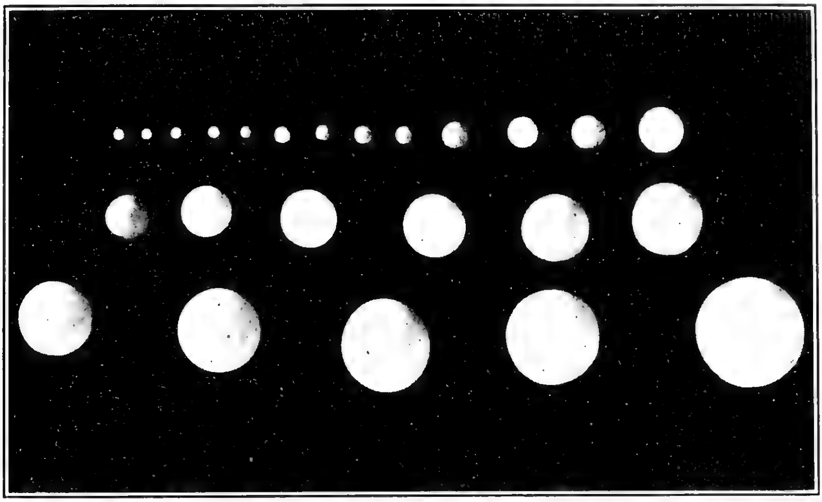
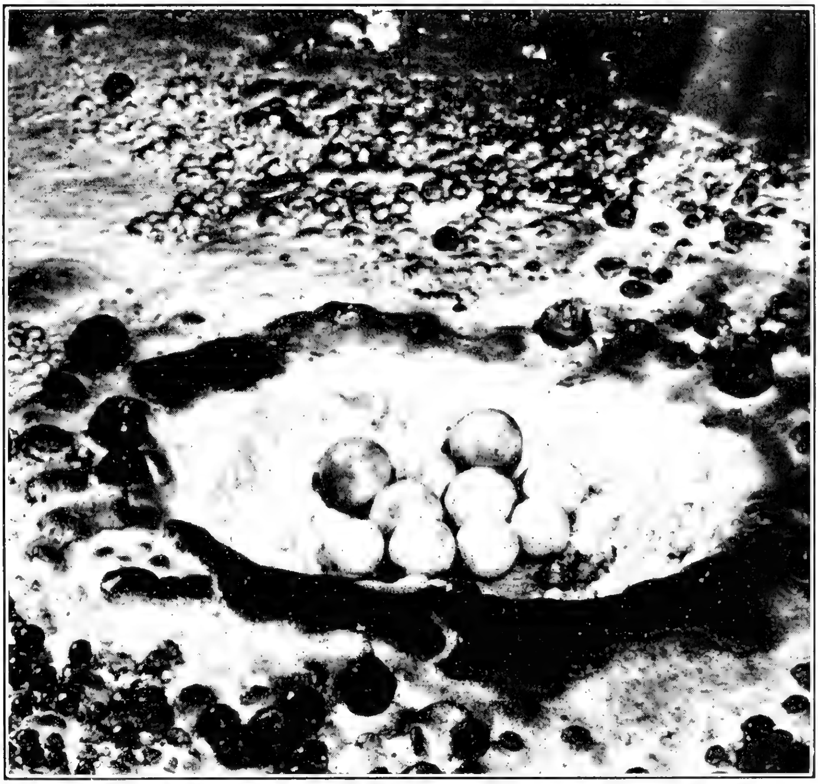
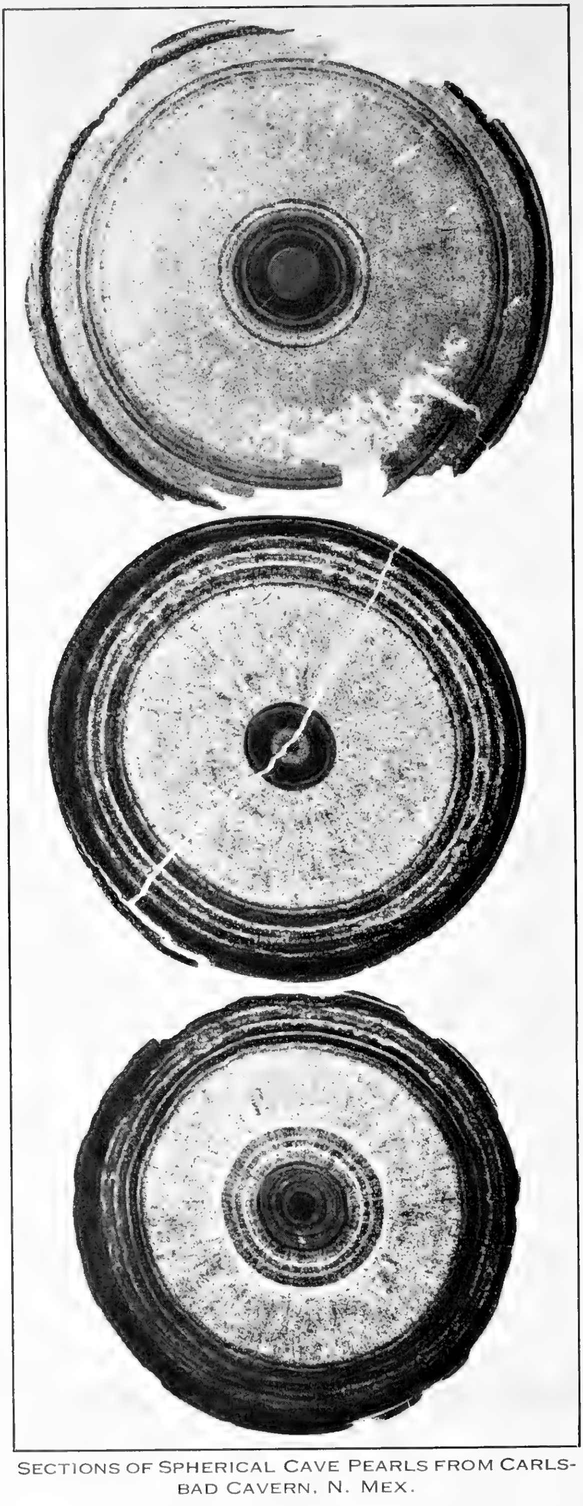




CAVE PEARLS FROM CARLSBAD CAVERN, N. MEX.

FOR EXPLANATION OF PLATE SEE PAGE 4



SECTIONS OF SPHERICAL CAVE PEARLS FROM CARLSBAD CAVERN, N. MEX.

FOR EXPLANATION OF PLATE SEE PAGE 4

SECTIONS OF OÖLITIC SAND FROM GREAT SALT LAKE, UTAH

FOR EXPLANATION OF PLATE SEE PAGE 4

PHOSPHATE ROCK FROM WYOMING SHOWING OÖLITIC STRUCTURE

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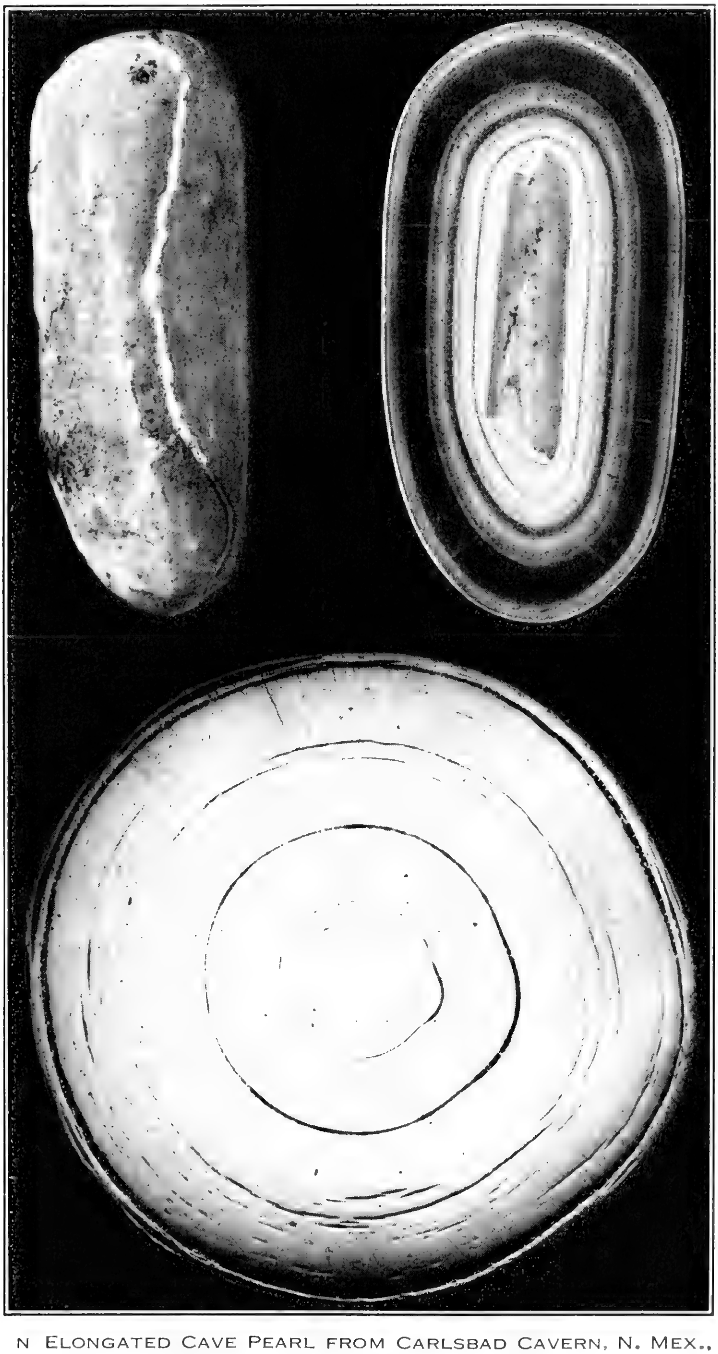

N ELONGATED CAVE PEARL FROM CARLSBAD CAVERN, N. MEX., AND SECTION OF AN OÖLITE OF NICKEL

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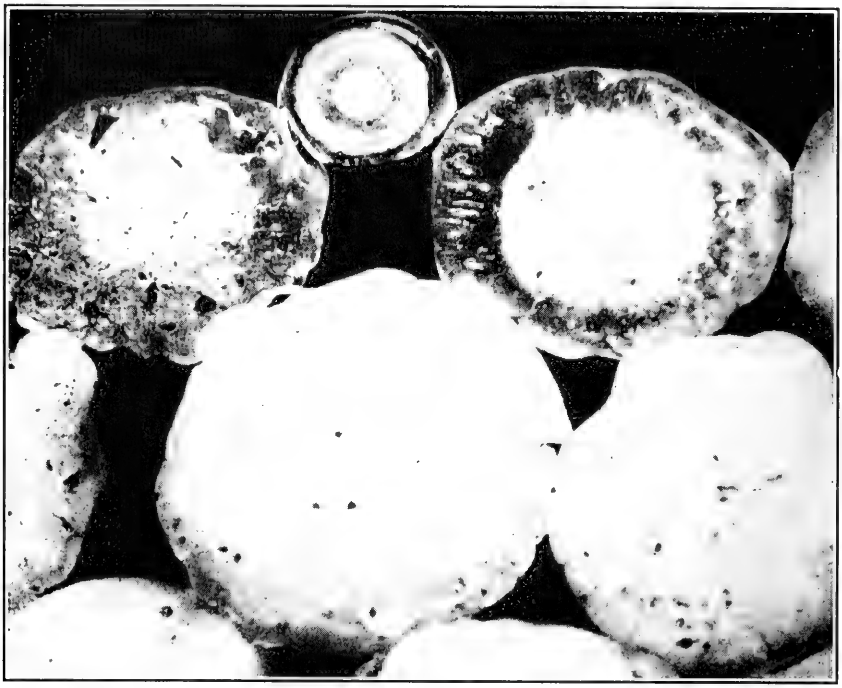

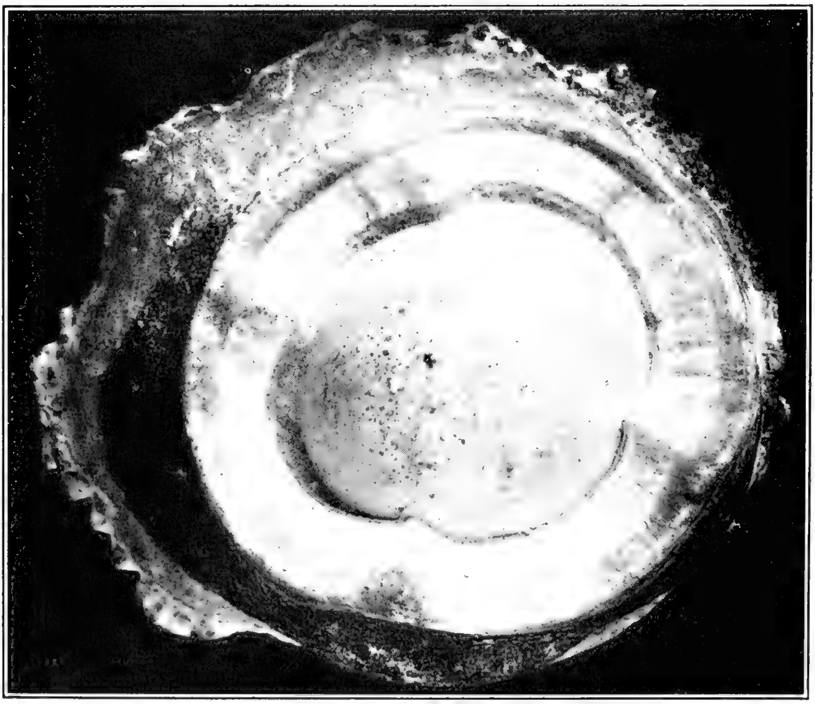

SPECIMENS SHOWING CONCENTRIC STRUCTURE

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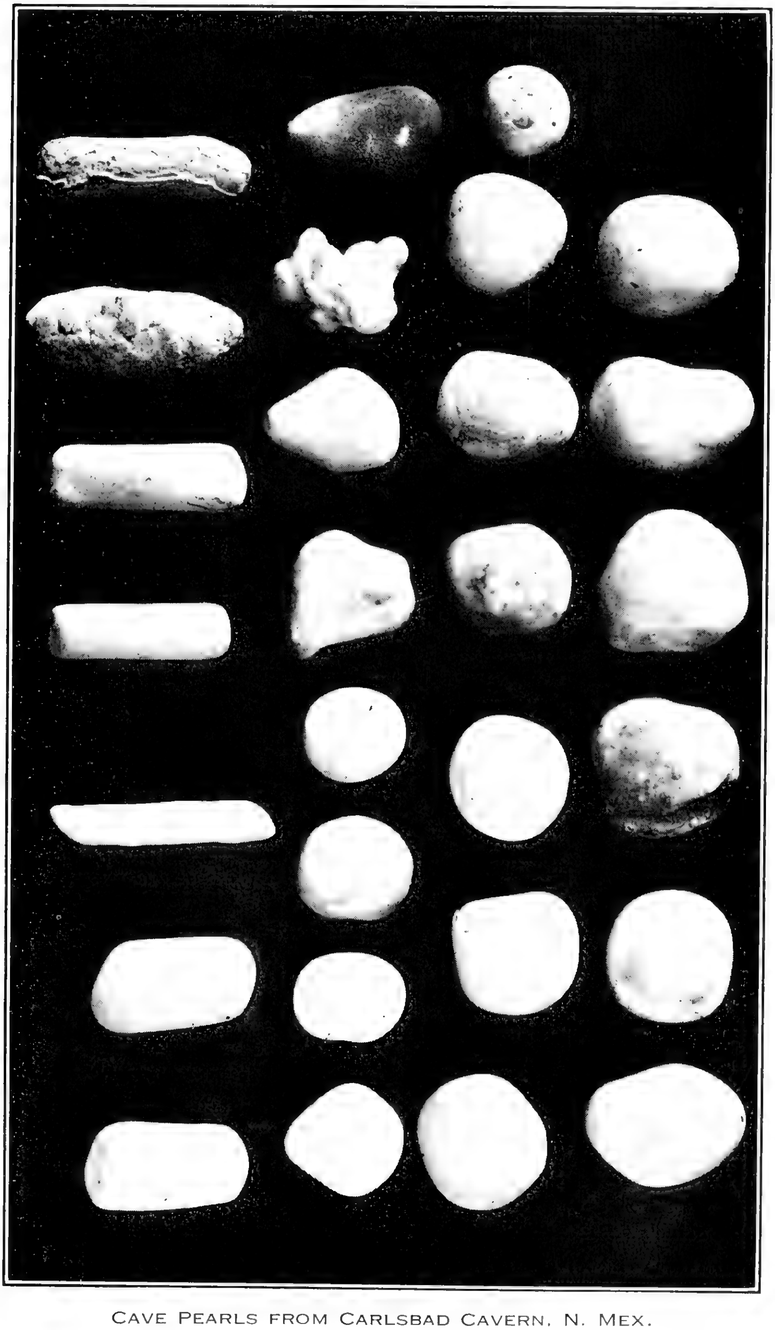
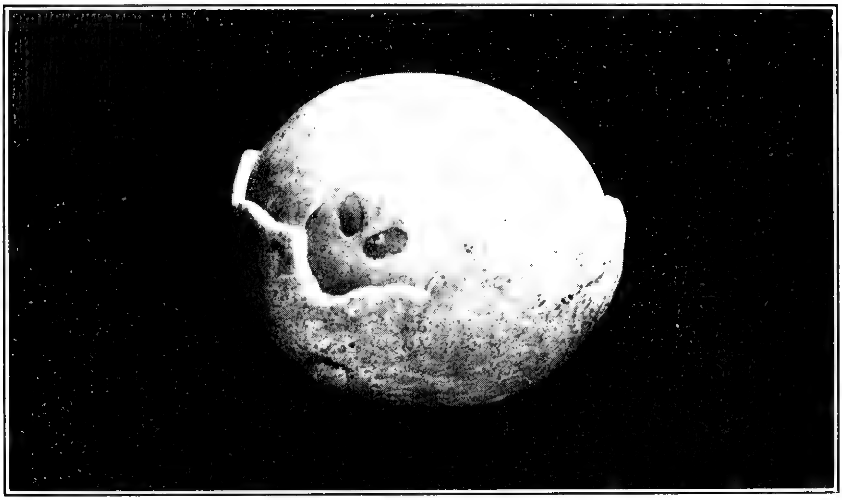
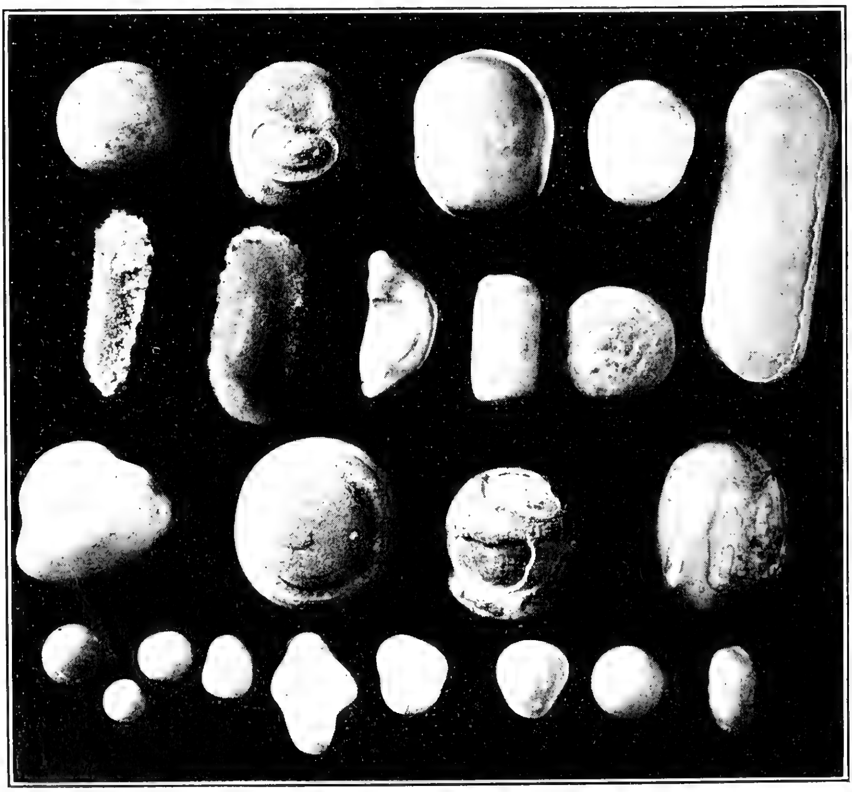


CAVE PEARLS FROM CARLSBAD CAVERN, N. MEX.

FOR EXPLANATION OF PLATE SEE PAGE 5





CAVE PEARLS FROM CARLSBAD CAVERN, N. MEX.

FOR EXPLANATION OF PLATE SEE PAGE 5

CONTRIBUTION TO THE TAXONOMY OF ASIATIC WASPS OF THE GENUS TIPHIA (SCOLIIDAE)

By H. W. Allen and H. A. Jaynes,

Of the Bureau of Entomology, United States Department of Agriculture

INTRODUCTION

Since 1920, workers on the Japanese beetle project of the United States Bureau of Entomology have been searching in the Orient for suitable parasites to introduce into the United States for use against the Japanese beetle in this country. In the course of this work a large amount of material on the genus *Tiphia* was gradually accumulated, and considerable information on the ecology and life history of a number of the species was gathered. Satisfactory determinations of these species, however, could not be obtained. The writers therefore began during the winter of 1926–27 a study of the material accumulated in the Japanese Beetle Laboratory and in the United States National Museum. It was soon found that a considerable number of species was represented. The original descriptions of many oriental forms proved unsatisfactory because most of the characters used in these descriptions appear, in the light of present knowledge, to have little or no diagnostic value. Fortunately, Mr. A. B. Gahan of the Bureau of Entomology was able to spend a few days examining types in the British Museum and comparing them with specimens sent him and with manuscript keys to species, and was able to indicate the identity of several species with previously described forms. In addition to these species, a number of others, new to science, are described in this paper.

The inadequacy of some of the descriptions is probably due in no small measure to the use of inferior optical equipment by the earlier workers on the group. The writers have found the wide field binocular microscope giving a magnification of about 60 diameters and a powerful artificial light almost indispensable for clearly revealing some of the minute characters that have been found most valuable in differentiating species. The large number of reared specimens of

known history at the disposal of the authors has proved a very great boon to basic taxonomic work in this group, and is probably an advantage not enjoyed to so great an extent by any previous workers on the genus.

The external structural characters of the two sexes differ so widely that association on morphological resemblances can safely be made only in isolated cases where some striking character is present in both. The sexes have been correctly associated in several species by rearings from known parentage. A number of species are still known in literature by different names for each sex; such a condition can be eliminated but slowly through rearings and more extensive collecting. Females have been selected as types whenever possible, because this sex possesses more valuable diagnostic characters, and is more important from the point of view of biological control.

This paper is a statement of the writers' present knowledge of the taxonomy of *Tiphia* from Japan, Chosen (Korea), China, and India. A more extended study should be made of the types from this region which are deposited in the museums of Europe, but at present the authors are not in a position to do this. Since considerable biological and economic data are, however, now awaiting publication, it is deemed advisable to pave the way by the publication of this preliminary taxonomic paper.

All of the types of new species described in this paper, along with a large number of paratype specimens, have been deposited in the United States National Museum. Wherever they could be spared, paratypes and determined specimens have been deposited in the British Museum, which, of all institutions, has the largest collection of types of *Tiphia* from eastern Asia. Similar material has been deposited in the collection of the Illinois Natural History Museum, which is rich in North American *Tiphia* worked over several years ago by J. R. Malloch, and in the collection of the Philadelphia Academy of Natural Sciences, which also has a large collection of *Tiphia*. Representative paratypes and much of the material not included in type series have been retained in the collection of the Japanese Beetle Laboratory.

The authors acknowledge the helpful assistance of A. B. Gahan, who not only compared many of their determinations with types, but also allowed them to use his notes on other species found in the British Museum which are not represented in North American collections; of S. A. Rohwer for the use of his notes on *Tiphia* and for helpful criticism; of Dr. J. Waterston, hymenopterist of the British Museum, for comparisons made with types, and for generously proffering the services of the British Museum; and of Dr. J. Masi for comparisons made at the Museo Civico de Storia Naturale, Genoa,

Italy. For additions to the collection of material, thanks are due to Messrs. C. P. Clausen, T. R. Gardner, J. L. King, K. Sato, T. P. Chao, C. Y. Wong, and various Japanese and Chinese assistants. Much helpful assistance has been received from Messrs. J. K. Holloway and R. W. Burrell of the Japanese Beetle Laboratory. Thanks are due also to Messrs. L. B. Smith and J. L. King for their encouragement in the study of oriental *Tiphia*.

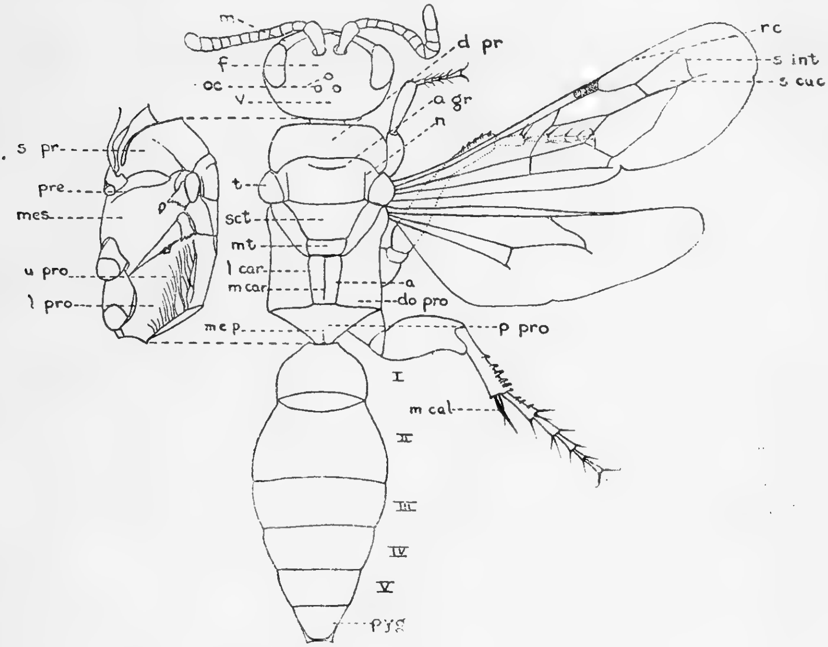


FIGURE 1.—OUTLINE SKETCH OF A FEMALE TIPHIA SHOWING DORSAL ASPECT IN TOTO, AND LATERAL ASPECT OF THE THORACIC REGION: *a*, AREOLA; *a gr*, ANTERO-MEDICAL GROOVE OF SCUTUM; *do pro*, DORSAL ASPECT OF PROPODEUM; *d pr*, DORSAL PRONOTUM; *f*, FRONT; *l car*, LATERAL CARINA OF AREOLA; *l pro*, LOWER PORTION OF SIDES OF PROPODEUM; *m*, MANDIBLE; *m c p*, MEDIAL CARINA OF POSTERIOR ASPECT OF PROPODEUM; *mes*, MESEPISTERNUM; *m cal*, MAJOR CALCARIUM OF THE HIND TIBIA; *m car*, MEDIAL CARINA OF THE AREOLA; *mt*, METATHORAX; *n*, NOTAULI OF SCUTUM; *oc*, OCELLI; *p, pro*, POSTERIOR ASPECT OF PROPODEUM; *pre*, PREPECTUS; *pyg*, PYGIDIUM; *r c*, RADIAL CELL; *sct*, SCUTELLUM; *s cu c*, SECOND CUBITAL CELL; *s int*, SECOND INTERCUBITAL VEIN; *s pr*, SIDE OF PRONOTUM; *t*, TEGULA; *u pro*, UPPER PORTION OF THE SIDE OF THE PROPODEUM; *v*, VERTEX

DIAGNOSTIC CHARACTERS

Although a large number of the terms in this paper have been used before in works on *Tiphia* or closely related groups, some uncertainty has developed in regard to the precise meaning of many of the terms employed. For the purpose of avoiding ambiguity, as well as to make the descriptions given of greater value to the student unversed in the taxonomy of Hymenoptera, some space is given in the present paper to the discussion and definition of characters.

Punctation.—The size, shape, depth, density, and uniformity of distribution of punctures vary greatly between species, and furnish many distinguishing characters in both sexes. In some species the punctures are round; in others they are elongated. The margin may be sharply outlined or vague, and, in one group, each puncture has an extended impressed area surrounding it, suggesting the term "*dimpled.*" There are often two, and sometimes three, distinct sizes of punctures in the same area. When the punctures of such an area are of two sizes the condition is termed *bipunctate*, and the larger punctures are called primary punctures and the smaller are called secondary punctures. When the secondary punctures are very small they are called *minute punctures.* This term is also applied to the smaller punctures in cases where there are secondary punctures of two sizes. The spaces between punctures are termed interspaces.

The primary punctures vary in density, but can be classified in three more or less distinct categories (pl. 2, fig. 9). When punctures are so grouped that each has at least three others nearer to it than the length of its own diameter, the condition is termed *first-degree density.* When the punctures are arranged in rows, each puncture separated from the proximate punctures in the same row by interspaces equal to or shorter than the diameter of the puncture, the condition is termed *second-degree density.* When the punctures are widely scattered, being separated by interspaces greater than their individual diameters, the condition is termed *third-degree density.*

Head.—The *vertex* extends from the occipital declivity to the lowest ocellus. The presence and distribution of certain minute punctures on the vertex, and their size, density, and regularity of distribution are diagnostic in both sexes of several species (pl. 4, fig. 28). The *front* extends from the lowest ocellus to the antennal fossae. In this region the degree of shagreening is diagnostic. In both sexes there are some differences between species in the presence or absence of a *carina* on the medial line just above the antennae; another specific difference is the presence or absence of a shallow *groove* extending along the top of this carina and continued above on the *impunctate stripe* which extends downward from the lowest ocellus. These characters are apparently not always constant within the species. The density of the primary punctures varies greatly between species and is a good diagnostic character, particularly in females. Primary punctures are usually denser on the lower front from eye to eye and, to a more limited extent, along the eye orbits toward the vertex, than elsewhere on the front. They are usually sparse in a region bordering the ocellar triangle below called the *preocellar region.* In the males, the height to which the secondary punctures extend medially and along the eye orbits, and the

degree to which they mingle with the primary punctures are valuable characters.

The density, erectness, and orientation of the hair would be a good character if it were not for the fact that this vestiture is easily rubbed off. The width of the face between the antennal fossa and the eye orbit, termed the *antennocular distance*, varies between species and forms a distinguishing character in males. The most prominent feature of the clypeus is the *median extension*. In the female it is nearly always truncate or faintly emarginate, but in the male the emargination varies sharply between species, and is an excellent character. Another good specific character in both sexes is the extent of the impunctate margin, measured in terms of its proportion to the whole *clypeoantennal distance*, which is the distance from the apex of the extension to the anterior edge of the antennal fossae. This distance is also used as a unit for measuring the *apical width* of the clypeal extension in the males, which is the distance between the two apical points, or, in species with truncate clypeus, of the truncate portion. The *lateral margin* of the clypeus, which includes the distance from the extension to the base of the mandibles, is anteriorly convex in some species (pl. 1, fig. 8), and straight in others.

The only reliable mandibular character in this group is found in the presence or absence of a medial longitudinal groove (pl. 3, fig. 21) in females. Dentation and coloration seem to have little value.

In a number of species of the *koreana* group the third antennal segment is conspicuously reddish. The flagellum is somewhat fulvous underneath in the females of many species, but this is rare in the males. In the males of some species there is a series of rectangular, fulvous spots on the underside of the antennae, extending to the tip.

Thorax.—The degree of shagreening and the size, shape, density, and uniformity of distribution of punctures vary as greatly on the thorax as on the front, and are defined in the same terms. A *transverse carina* separating the dorsal and the anterior aspects of the pronotum is almost always strongly developed in males, but varies enough in females to be a fairly good character if not too rigidly applied. It may be lacking medially and it may have the edge flattened. In the females, the hindmost punctures of the pronotum may be concentrated in a densely punctate, *transverse discal band*. The medial extension of the punctate, anterior portion of the dorsal aspect may be greater or less than that of the impunctate, posterior portion, though this is somewhat unreliable as a character when there is also a narrow, medial, impunctate emargination of the punctate portion.

On the *side of the pronotum* (fig. 1, *s pr*), which lies in a nearly vertical plane, the most valuable character in both sexes is the *groove* which crosses the center of the region from a point near the terminus of the transverse carina to the alar angle. This groove may be entirely absent or it may be present, complete, or only partially developed, straight or broadly curved, deep or shallow, broad or narrow, uninterrupted or crossed at frequent intervals by diagonal rugae. The groove is described as viewed from a position perpendicular to the surface upon which it occurs and not from in front. Punctures on the side are also valuable characters though not often found.

The *scutum* of the female usually has lateral notauli and a separate crescent-shaped *antero-medial groove* (pl. 1, fig. 6). In some species the notauli and the *antero-medial groove are connected at the* antero-lateral corner, and are then termed *continuous* (pl. 1, fig. 5).

The punctures of the *mesepisternum* (fig. 1, *mes*) have diagnostic value in the males. The posterior slope is densely covered with secondary punctures in all species, and this is usually true of a narrow area posterior to the prepectus. The lower disk is usually sparsely punctate at most, but on the upper disk all degrees of bipunctation occur. Shagreening is also diagnostic. There are a few species in which in both sexes there is a plainly visible groove (pl. 1, fig. 1) adjacent and parallel to the posterior border, sometimes extending upward toward the spiracle on the polished summit called the *subalar callosity*. No trace of this character occurs in most species.

The width of the impunctate apex of the *scutellum* varies among the males, but is rather difficult to define because the actual apex is indefinite.

On the *metanotum* the principal diagnostic characters are the size of the punctures as compared with those of the scutellum and the presence or absence of a medial impression or callosity.

Legs.—The femora and tibiae are usually black, but in the females of some species the femora or the tibiae, or both, are bright red. Such color characters have proved constant for a long series of specimens obtained from one locality, but may not apply so well to specimens taken over a wide geographical or climatic range. The presence or absence of a *longitudinal groove* (pl. 3, fig. 22) on the hind basitarsus is an excellent diagnostic character with the females, and divides the species described in this paper into two nearly equal parts. In the females of some species the larger of the two long spurs on the hind tibia, termed its *major calcarium* (fig. 1, *m cal*), tapers uniformly from the base to the apex (pl. 1, fig. 4), while in other species it is distinctly wider near the middle than at the base (pl. 1, fig. 3). On the outside of the hind basitarsus there occurs a group of specialized spines which range in shape from

straight lanceolate to pricklelike (pl. 3, figs. 22 and 23) and in arrangement from a straight row to an irregular group, with or without one of the same kind of spines at the extreme apex.

Wings.—The tegulae are occasionally much longer than wide. They are usually thick and dense, opaque black, but in some species they become semi-transparent and bright red or brownish. Shagreening is occasionally found, though fainter than on the front. A marginal groove is present in some species, and a faint marginal impression on the outside is even more common. The wings seem to have very few diagnostic characters in the female. In the male, the apical extension of the radial cell varies greatly between species, and is considered to be equal to the second cubital cell when a line drawn from the lower outer angle of the second cubital cell perpendicular to the costa touches the end of the radial cell for a part of its length. It may be either longer (pl. 4, fig. 25) or shorter (pl. 4, fig. 26) than this. Smokiness, associated with distinctness of the hyaline tracings, varies among species. but can not be finely differentiated. A peculiar tracing in the first cubital cell below the stigma is termed the *first cubital mark* (pl. 1, fig. 7). Vein curvatures and ratios of comparison between the lengths of different abscissae appear to be highly variable within the species.

Propodeum.—The principal characters of the propodeum are the shape (pl. 2, figs. 10 to 14), and the length of the *areola* (fig. 1, *a*) or dorsal enclosure, the nature and extent of the carinae, the presence or absence of shagreening, striae, and minute setigerous punctures on the area beneath the parallel rugae on the lower aspect termed the *lower portion of the side* (fig. 1, *l pro*). The conformation of the areola in the male is quite variable within the species, and is therefore unreliable in this sex. The length of the areola is expressed in terms of its width at the anterior limit. The outside carinae may or may not be bordered by grooves. The grooves, when present, may or may not be interrupted by many transverse ridges. When interrupted in this way the groove is called *crenulate*. The *posterior aspect* appears to offer few good characters. Its sculpturing is rather faint and is variable within species, but the length of the medial carina is fairly constant, and is perhaps the best character of this region.

Abdomen.—The first abdominal tergite (fig. 1) furnishes a number of good characters. No median transverse ridge or groove, such as is common in North American species, has been found to occur on any of the Asiatic species examined. In the *koreana* group, however, there occurs a *deep preapical groove* (pl. 2, fig. 15) which is overlapped at the middle, and is an excellent diagnostic character, although apparently easy to overlook because of its proximity to the normal apex of the segment. This groove is always associated with

a peculiar type of dimpled punctures. Patches of dense, minute punctures on the *anterior aspect* and the presence and constitution of the *preapical band* of punctures just before the apex of the tergite are of value in the females. The triangular first sternite may be coarsely punctate, densely and minutely punctate, or impunctate. It has *lateral grooves*, (pl. 4, fig. 31), which are anterior prolongations of the usual posterior transverse fossa. The fossa is frequently crossed by many transverse ridges or *crenulae* and is then termed crenulate. The grooves vary in length from less than one-fourth to three-fourths the length of the sternite, though this character should not be too rigidly applied. Just anterior to the constricted portion of the first sternite there is a shield-shaped sternal sclerite termed the *escutcheon* (pl. 4, fig. 31.)

The tergites of the intermediate abdominal segments offer diagnostic characters in the form of variations in the density and distribution of punctures, the presence or absence of dense, erect, brown pile, of marginal grooves, of vestigial rows of minute punctures (pl. 4, fig. 30), and of apical rows of highly specialized hairs. The impunctate apex varies in width, and is measured in terms of the width of the nearest and largest dorsal primary punctures, without considering the thin, membraneous extension of the apex, which is present in many specimens.

The sternites appear to have few useful characters among the females, though in the *bicarinata* group the presence of well differentiated apical rows of hairs is quite constant and conspicuous. In the Asiatic males, nearly all species have the minute *lateral denticle* on the fifth sternite (pl. 4, fig. 27) which readily differentiates them from most of the eastern North American species, in which this character is absent. In some Asiatic males a similar process is developed on the fourth sternite, with possible traces on the segments anterior to the fourth, and in other species a conspicuous orifice is present under the denticle of the fifth sternite.

The *hypopygium* of the female is usually very uniform, but in two species it possesses diagnostic characters in the form of a narrow, median, *impunctate line* (pl. 1, fig. 2). The impunctate line, which is uniformly present in males, has some useful diagnostic characters in its contour and in the nature of the tufts of hair bordering it.

The *pygidium* of the male is of little value for determinations, but in the female (fig. 1, *pyg*) it offers a number of highly valuable specific characters. In most species the punctures are confined to the upper three-fifths, but in some they extend nearly to the tip. In a few species it is entirely and deeply rugose. The apical half may be smooth and highly polished, shagreened, or covered with shallow wrinkles quite different from the rugae mentioned above.

The lower portion of the punctate area may or may not have a central impunctate spot (pl. 4, fig. 32) in the form of an *emargination* of the apical border.

The genitalia of the male (pl. 3, fig. 17) consist of the *first* and *second genital segments* and a number of accessory appendages. On the ventral side of the second genital segment, and more or less closely connected with it, are two pairs of claspers. The larger pair is termed the *outer claspers*, and the smaller pair the *inner claspers*. The second genital segment usually terminates in a downward and inward-twisted process termed the *apical hook*. The *aedeagus* is characterized by a proximal and a distal portion, which are more or less definitely separated by a constriction. On the distal portion *apical lobes* and *lateral processes* are usually differentiated. Very few or no differences have been noted in the genitalia of closely related species of well-defined groups. There are, however, a number of well-marked differences between males of the different groups studied in respect to the conformation of both pairs of claspers, of the apical hooks of the second genital segment, of the degree of angulation or convexity of the inner hind margin from the apical hook to the base of the aedeagus, and in the apical lobe and lateral process of the aedeagus.

Throughout the group there is a marked degree of antigeny. The males are uniformly much smaller than the females. Each sex has specific diagnostic characters not present in the other sex, such as in the wing venation and in the mesepisternal bipunctation in the male, and in the hind basitarsal groove in the female, but even in the case of such characters as the groove on the side of the pronotum, which is developed in both sexes, there is no fixed degree of correlation.

UNIFORM CHARACTER OF THE GENUS

An effort has been made to use only characters of diagnostic value in the descriptions in this paper. In order to avoid undue repetition, it may be stated here that all species described in this paper possess the following characters, unless otherwise specified.

Female.—Vertex without dense, minute punctures extending dorsally forward from the occipital area. Front with its hairs directed more strongly backward than outward; primary punctures round and deep; surface not shagreened; without medial carina, impunctate stripe, or groove. Clypeus with its lateral margin straight; its extension truncate or only very slightly emarginate; with an impunctate margin defined by an even row of punctures. Mandibles without a median groove between the usual upper and lower grooves. Antenna with its third joint distinctly shorter than its greatest width; first joint not angulate apico-ventrally; flagellum black

throughout. Pronotum not shagreened; with its transverse carina not complete medially. Sides of pronotum without a groove across center, but with fine, anastomosing rugae in ventral angle. Scutum with its notauli and antero-median groove not continuous. Mesepisternum on the posterior slope without a premarginal groove. Metanotum without an apical callosity or median groove or impression. Legs black, except for variable reddish coloration on the less exposed surfaces; without groove on hind basitarsus. Tegula without incised or impressed lines on outside border; inner corner not conspicuously produced or upturned; length not exceeding width; color black and opaque without shagreening. Wings smoky, with first cubital mark not present. Propodeal areola with inclosed areas smooth and free from sculpturing. Lower portion of sides of propodeum without dense, setigerous hairs. Posterior aspect of propodeum coriaceous laterally. First abdominal tergite without a median patch of dense, minute punctures and without a preapical groove that is broadly overlapped in the middle; no dimpled primary punctures on the posterior dorsum. First sternite with dense, minute, setigerous covering on its disk, this covering not considered to be sculpturing. Tergites 2 to 5 without a marginal line or groove extending over the median region, and without dense, erect pile, vestigial apical rows of minute punctures, or other unusual arrangement of punctures as described for various species. Pygidium not longitudinally carinate, with impunctate emargination of the punctate area, and not visibly shagreened on the apical impunctate surface.

Male.—Vertex devoid of a dense patch of secondary punctures extending dorsally; primary punctures of vertex conspicuously denser in a medial patch behind the ocellar triangle than on either side. Front not shagreened, its primary punctures round and deep, of first-degree density except on the preocellar region where they are of third-degree density; without medial carina, groove, or stripe. Impunctate margin of clypeal extension drawn to a thin edge. Antennae entirely black. Pronotum not shagreened, its transverse carina complete and sharply erect. Mesepisternum not shagreened, lacking the premarginal groove along the posterior surface. Legs black. Tegula black, opaque, without shagreening or marginal grooves or impressions. Wings smoky, with the hyaline lines distinct, first cubital mark not present. Tergites without erect, brown pile or margins with linear grooves over the dorsum. First tergite without an antero-median patch of dense secondary punctures. Fifth sternite with lateral denticles beneath which there is no orifice; similar processes not present on preceding sternites. Hypopygial median impunctate stripe of uniform width.

RELATIONSHIPS

As the result of the study of a long series of specimens, some of which are associated with unpublished biological notes, the writers are convinced that within the genus *Tiphia* there are a number of sub-groups of closely related species. This relationship is indicated in the accompanying list of species, in which the *popilliavora* group of five species is possibly the least specialized. Varying in different directions from this central group are other groups, as well as a number of species which we have not yet been able to associate with any group. The other groups which have been recognized are the *koreana* group of eight species, the *rufomandibulata* group of seven species, the *bicarinata* group of four species, the *malayana* group of three species, the *agilis* and the *capillata* groups of two species each, the *vernalis* complex, the species *totopunctata*, which is quite distinct, and nine species, headed by *matura*, which have some points of relationship but are not considered as forming a group of closely related species.

LIST OF SPECIES

Koreana group
- *koreana*
- *ovidorsalis*
- *antigenata*
- *assamensis*
- *tegitiplaga*
- *autumnalis*
- *fossata*
- *communis*

totopunctata

Rufomandibulata group
- *sternodentata*
- *singularis*
- *notopolita* var. *notopolita*
- *notopolita* var. *intermedia*
- *rufomandibulata*
- *sternocarinata*
- *brevicarinata*
- *lyrata*

Capillata group
- *capillata*
- *levipunctata*

Popilliavora group
- *popilliavora*
- *phyllophagae*
- *ovinigris*
- *inconspicua*
- *nervidirecta*

Malayana group
- *malayana*
- *brevistigma*
- *compressa*

Bicarinata group
- *bicarinata*
- *brevilineata*
- *cilicincta*
- *fukiensis*

Agilis group
- *asericae*
- *agilis*

vernalis

Miscellaneous species
- *matura*
- *pullivora*
- *biseculata*
- *pigmentata*
- *clauseni*
- *longitegulata*
- *latistriata*
- *minutopunctata*
- *nana* (?)

All of the species in which the male is known, except certain members of the *bicarinata* group, have a tooth or an orifice on the side of the fifth sternite. *Cilicincta* and, usually, *bicarinata*, are devoid of sternal denticles which in *fukiensis* are only weakly developed. This deficiency, together with the peculiar apical ciliate rows of bristles on the abdominal segments and the wholly rugose pygidium of the female, distinguishes this group from the others, although the

basitarsal groove indicates greater affinity with the *malayana*, *popilliavora*, and *agilis* groups and with *vernalis* than with the others.

The presence of a basitarsal groove in the female is associated with stout lanceolate spines (pl. 3, fig. 22) on the outside of the basitarsus, terminating in a spine of the same type at the apex. It is also associated with a major calcarium which is distinctly wider near the middle than toward the base, and characterizes the *malayana*, *popilliavora*, and *agilis* groups, the species *vernalis*, and all species listed with *matura* except *nana*, in which the female is not known. In the species lacking the groove, the outside of the basitarsus is armed with spines which are more or less prickle-shaped but lacks a spine of the same type at the apex, and the major calcarium of the hind tibia tapers from the base, or at least is not wider near the middle than at the base.

The *vernalis* complex as a whole is generalized like the *popilliavora* group, differing most noticeably in the male, which has the mesepisternum much less densely beset with secondary punctures, the radial cell far exceeding the second cubital cell, and a peculiar, wedge-shaped, impunctate area on the hypopygium.

The *agilis* group also is somewhat generalized, but differs from the *popilliavora* group in that they are smaller and have the tegula delicate, red, and semitransparent. The mesepisternum of the male is somewhat less densely beset with secondary punctures and the radial cell exceeds the second cubital cell.

In the *malayana* group the sculpturing of the pygidium is characteristic, the pygidium being unusually smooth and free from wrinkles or shagreening on the apical impunctate portion. In *malayana*, the only species of this group in which the male is known, the radial cell far exceeds the second cubital cell and the mesepisternum is comparatively scantily beset with secondary punctures, as in *vernalis*, but the impunctate area of the hypopygium is linear and not wedge-shaped.

In the species listed under *matura* there are few characters of group significance aside from those associated with the grooved basitarsus. *Longitegulata* is a very small species with a peculiar, elongate tegula. Both *biseculata* and *pigmentata* have brightly colored leg segments, but they differ in numerous characters from the red-legged *capillata* group, from each other, and from the species in which there is no bright pigmentation.

The two species in the *capillata* group, although lacking the basitarsal groove, are somewhat more generalized than other known Asiatic species in which this condition exists, and, while they differ

from the species in the groups in which the basitarsal groove is markedly lacking, they may not be closely enough related to each other to comprise a separate group. There are marked differences between the two species in vestiture and density of punctation on the front and the pronotum.

The *rufomandibulata* group is characterized by a uniformly tapering major calcarium of the hind tibia and by the basitarsal spines typical of those species lacking the basitarsal groove. The propodeal areola does not differ much from the generalized *popilliavora* group, except in the five-carinate species *lyrata.* Among the four species of the group in which males are known there is, in this sex, an orifice on either side of the fifth sternite, a character not found in any of the other species listed above in which males are known. It should be noted, however, that in *singularis* and *sternodentata* the radial cell much exceeds the second cubital cell, while it is scarcely equal in the other species. The females of *singularis* and *sternodentata* are not known, and these species have therefore been associated only tentatively with this group.

The *koreana* group is more sharply defined than any of the others. Both males and females have a deep, overlapped groove on the preapical dorsum of the first tergite, preceded by dimpled punctures. Although several species in this group have been described previously, this character seems to have been overlooked, probably because the overlapped edge of the groove has been confused with the apical margin of the tergite. The groove can readily be identified by tracing the edge laterally to a point where the groove opens from under the overlapping portion, somewhat anterior to the true apex of the segment. Some, but not all of the species, have peculiar, short, dense, erect, brown pile on the abdomen, which may or may not be present in both sexes and on both tergites and sternites.

The relationships between the Asiatic *Tiphia* and the species native to eastern North America where introductions are being made have not been thoroughly worked out. The authors point out, however, that they have not yet seen any native *Tiphia* resembling those of the *koreana* or the *bicarinata* groups, and that most of the species introduced from the Orient have denticles or orifices plainly visible on the fifth sternite in the male, while very few of the native species are thus equipped. The sternal denticle in the male is a useful point in making preliminary determinations of individuals recovered in the field. The presence of a groove on the hind basitarsus of the female and the variation in elongation of the radial cell of the male occur in local *Tiphia* to about the same extent that they do in the oriental forms.

KEY TO SPECIES: FEMALES

1. Hind basitarsus grooved ---------- 18.
 Hind basarsus not grooved ---------- 2.
2. First tergite with a very deep preapical groove overlapped at the middle by its anterior margin; the dorsal punctures shallow and dimpled ---------- 11.
 First tergite at most with an impressed preapical band; the dorsal punctures not dimpled ---------- 3.
3. Pygidium deeply punctate or rugoso-punctate on not more than the basal three-fifths ---------- 4.
 Pygidium deeply rugoso-punctate three-fourths the distance to its apex; scutum with its notauli and its antero-medial groove continuous.
 (9) (Chosen) **totopunctata**, new species.
4. Tibiae black; front devoid of dense appressed hairs directed strongly outward from bases of antennae ---------- 6.
 Tibiae bright red ---------- 5.
5. Femora black; front with dense, appressed hair which is directed strongly outward at the base of the antennae ---(17) (India) **capillata**, new species.
 Femora of last two pairs of legs bright red; front with scanty, erect hairs not directed strongly outward ----(18) (India) **levipunctata**, new species.
6. Second intercubital vein straight, joining the radius at a sharp angle; first tergite at most with only a few minute punctures on its medio-anterior aspect ---------- 7.
 Second intercubital vein sinuous, joining the radius in a broadly rounded angle; first tergite usually with a broad, median patch of dense, minute punctures on its anterior aspect; tegula nearly black, with two separate marginal grooves, one on the outer and the other on the posterior margin, both terminating in an abrupt, inward directed hook at the outer hind angle ----------(13) (Japan, China) **rufomandibulata** Smith.
7. Propodeal areola without additional longitudinal carinae between the usual two lateral and median carinae ---------- 8.
 Propodeal areola with an additional longitudinal carina on each side of the median carina, between the median and the lateral carinae.
 (16) (Burma, China) **lyrata** Magretti.
8. Dorsal aspect of propodeum without an additional short, transverse carina on each side of the areola and immediately anterior to the transverse carina ---------- 9.
 Dorsal aspect of the propodeum with a short carina on each side of the areola as described above ------(15) (China) **brevicarinata**, new species.
9. Anterior, constricted portion of first sternite punctate or coarsely coriaceous, without a definite median keel flanked by deep, short grooves supported on the outside by high, sharp carinae; tegula with a groove or impression, at least on posterior margin ---------- 10.
 Anterior, constricted portion of first sternite not punctate or coarsely coriaceous, with a definite keel, flanking grooves, and carinae as described above; tegula without marginal grooves.
 (14) (China) **sternocarinata**, new species.
10. Metanotum mostly impunctate; tegula with groove rarely present on the outer margin.
 (12) (China) **notopolita**, new species.
 Metanotum sparsely and broadly punctate, usually with a median patch of dense, minute punctures; tegula with impression or groove usually present on the outer margin.
 (12) (Chosen) **notopolita**, new species, **intermedia**, new variety.

11. Tergites 3 to 5 (sometimes only 3) with erect, brown pile much shorter than the usual hairs____15.
Tergites 3 to 5 with only the usual long, irregular, yellow hairs_________12.
12. Posterior slope of the mesepisternum with a premarginal groove parallel to the posterior edge; or if groove lacking, first sternite with its median fossa not crenulate____13.
Posterior slope of the mesepisternum without a premarginal groove, though sometimes with a vague impression which resembles a groove in certain lights; first sternite usually with a shallow, crenulate median fossa; pygidium usually with a strong, median, carinate wrinkle.
(8) (China) **communis**, new species.
13. Punctures at center of tergite 3 much sparser than those caudad or cephaled of that region____14.
Punctures at center of tergite 3 scarcely less dense than those caudad or cephalad of that region; secondary punctures of tergites 3 and 4 well differentiated from the primary punctures; first sternite with a deep median fossa__________________________(7) (Chosen) **fossata**, new species.
14. Median carina of areola nearly obsolete, replaced by irregular punctures, anterior portion expanded laterally; first sternite with a polished, impunctate, longitudinal stripe__________(6) (Chosen) **autumnalis** Rohwer.
Median carina ending just before apex of the areola, not much expanded anteriorly; first sternite with a longitudinal median row of closely spaced punctures, but without polished, impunctate stripe.
(5) (Japan) **tegitiplaga**, new species.
15. First tergite with a row of very fine punctures just behind its preapical fold; pygidium not medially carinate, scarcely wrinkled on apical half.
(2) (Chosen) **ovidorsalis**, new species.
First tergite without a well defined row of punctures along posterior edge of premarginal fold____16.
16. Tergites with their brown, pilose areas very dense, and visible from any position, the brown pile abundant on sides as well as on the dorsum of the tergite________________________________(1) (Chosen) **koreana** Rohwer.
Tergites with their brown, pilose areas beset with very short or sparse pile, often visible only in profile against a light background, and becoming sparser at the sides____17.
17. Apical callosity of metanotum densely and minutely punctate; vertex devoid of a dorso-medial row of minute punctures.
(3) (China) **antigenata**, new species.
Apical callosity of metanotum without definite, minute punctures; vertex with an irregular row of minute punctures.
(4) (India) **assamensis**, new species.
18. Pygidium deeply punctate or rugose-punctate on not more than the basal three-fifths____20.
Pygidium deeply rugose (not wrinkled) to the apex____________________19.
19. Punctures of the pronotum evenly distributed; sixth sternite with a median, longitudinal, impunctate line at least as long as the tapering part of the sclerite_______________(27) (Japan, Chosen, China) **bicarinata**, Cameron.
Punctures of the pronotum much denser on the posterior margin than elsewhere on the punctate portion; median, longitudinal, impunctate line on the sixth sternite shorter than the tapering portion of the sclerite.
(28) (Chosen) **brevilineata**, new species.
20. Femora of last two pairs of legs black, at least on the outer, exposed parts; tibiae rarely red____22.
Femora of the last two pairs of legs wholly bright red_________________21.

21. Tibiae usually blackish; preapical band of the first tergite well differentiated; abdominal tergites 2 to 4 without shallow vestigial punctures in a row just caudad of the large, preapical, setigerous primary punctures.
(37) (China) **pigmentata**, new species.
Tibiae red; preapical band of the first tergite not differentiated; tegites with shallow punctures as described above.
(36) (Japan) **biseculata**, new species.
22. Tegula at most only slightly longer than broad — 23.
Tegula nearly twice as long as broad, light red; a small species.
(39) (China) **longitegulata**, new species.
23. Side of pronotum without well-differentiated groove across the center, or, if present, shallow and interrupted at frequent intervals — 33.
Side of pronotum with a well-differentiated groove across the center uninterrupted for a distance at least one-half the length of the sclerite — 24.
24. Tegula black and opaque, except along the outer edge, or, if red, not transparent and thin — 25.
Tegula wholly red, very thin, and semitransparent; pygidium with a distinct, apical, impunctate emargination in the basal, rugose half.
(32) (Japan, Chosen) **agilis** Smith.
25. Punctures of the punctate part of the pronotum much larger and denser in a line just anterior to the impunctate area than on the lateral disks of pronotum — 30.
Punctures of the punctate part of the pronotum at most only slightly larger or denser in a line just anterior to the impunctate area than on the lateral disks of pronotum — 26.
26. Pygidium wrinkled and strongly shagreened on impunctate portion; carina of the posterior aspect of propodeum only rarely flattened, with the bordering grooves, if present, vague and interrupted — 29.
Pygidium very smooth and free from wrinkles or shagreening on impunctate portion; carina of the posterior aspect of propodeum usually bordered on each side by a narrow groove, its crest strongly flattened — 27.
27. Dorsal aspect of propodeum without a diagonally longitudinal carina laterad of the lateral areolar carina; sides of pronotum above the groove without numerous, widely separated punctures — 28.
Dorsal aspect of propodeum with a diagonally longitudinal carina laterad of the lateral carina; sides of pronotum above the groove with numerous, widely separated punctures; groove of hind basitarsus vestigial, less than one-fifth the length of the joint.
(26) (Philippines, China) **compressa** Smith.
28. First sternite broadly coriaceous on the constricted base; stigma extending in a broadly rounded curve beyond the point of fusion with the radius; groove of hind basitarsus deep, and at least one-half the length of the joint — (24) (Borneo, China) **malayana** Cameron.
First sternite not sculptured on the constricted base; stigma abruptly truncate at the point of fusion with the radius; groove of hind basitarsus shallow, vestigial, though nearly half the length of the joint.
(25) (India) **brevistigma**, new species.
29. Frontal punctures mostly of first-degree density; areola at most scarcely more than twice as long as wide; metasternum with only one point to each lateral apex, proximal to the hind coxa.
(34) (India) **matura**, new species.
Frontal punctures of third-degree density at least on upper half; areola nearly three times as long as wide; metasternum with two distinct points to each lateral apex proximal to hind coxa.
(22) (China) **inconspicua**, new species.

30. Front, vertex, and pronotum not shagreened; second intercubital vein strongly curved--31.
Front, vertex, and pronotum conspicuously shagreened; second intercubital vein nearly straight; punctures on lateral disks of dorsal pronotum sparse, but nevertheless distinctly primary punctures.
(23) (China) **nervidirecta**, new species.
31. Vertex with a narrow series of minute punctures extending upward medially from occipital region toward ocelli; lateral disks of dorsal pronotum bearing primary as well as secondary punctures.
(19) (Japan, Chosen, China) **popilliavora** Rohwer.
Vertex without minute punctures extending in median line from occipital region toward ocelli; lateral disks of dorsal pronotum bearing sparse punctures, all of which are smaller than the largest primary punctures in the transverse discal band---------------------------------------32.
32. Transverse discal band of pronotum with several punctures on either side of the medial patch, which are very distinctly larger than those adjacent to them or those in the punctate angle anterior to the tegula; punctures on latero-dorsal disks of pronotum mostly secondary punctures.
(20) (Chosen, China) **phyllophagae**, new species.
Transverse discal band of pronotum without a series of several punctures on either side conspicuously larger than the others on the band, all of nearly the same size as those in the punctate angle anterior to the tegula; punctures of latero-dorsal disks of pronotum mostly small primary punctures------------------------(21) (Chosen) **ovinigris**, new species.
33. Hindmost punctures of tergites 2 to 4 not in separate bands, or, if so, removed medially from the apices by a distance only slightly greater than their width--36.
Hindmost punctures of tergites 2 to 4 in well-differentiated bands, at center only one puncture wide, and removed from the apex by several times the width of the band; usually with a narrow, medial area of dense, minute punctures on the anterior aspect of the first tergite-------------------34.
34. Propodeal areola with nearly parallel sides; metathorax with only minute punctures, which are much smaller than those of the scutellum; preapical band of the first tergite with its medial punctures well separated and definitely outlined---35.
Propodeal areola much narrower at the apex than at the base; metathorx with several primary punctures nearly as large as the largest of the scutellum; preapical band of the first tergite with its anterior margin abruptly impressed and its medial punctures more or less coalesced with the impressed area and with indefinite margins.
(40) (Chosen, Japan) **latistriata**, new species.
35. Lower front not shagreened, with several distinct sizes of punctures intermingled over a broad area, the coarsest primary punctures distinctly of third-degree density---------(41) (China) **minutopunctata**, new species.
Lower front shagreened, with coarse punctures, mostly of first-degree density, developed to the exclusion of other sizes, though becoming smaller toward the antennal fossae----------(38) (India) **clauseni**, new species.
36. Transverse carina of pronotum lacking for nearly the whole width of dorsal aspect---38.
Transverse carina of pronotum complete, or at most with a gap at the center less than half the dorsal breadth of the pronotum-------------------37.

37. Dorsal aspect of vertex with several minute punctures extending forward in a diminishing series toward ocellar trangle on medial line; mandibles with a shallow, median, longitudinal groove; tegula blackish.
(19) (Japan, Chosen, China) **popilliavora** Rohwer.
Dorsal aspect of vertex without such minute punctures; mandibles devoid of a definite medial, longitudinal groove; tegula thin and red.
(31) (Chosen, Japan) **asericae**, new species.
38. Medial carina on posterior aspect of propodeum complete or nearly so; impunctate apex of pronotum usually with one or more short, shallow, medial, longitudinal grooves_____(33) (Chosen, China) **vernalis** Rohwer.
Medial carina on posterior aspect of propodeum absent or very short.
(35) (India) **pullivora**, new species.

KEY TO SPECIES: MALES

1. Fifth sternite with a denticle or orifice on each side____________________3.
Fifth sternite without a denticle or orifice on each side_________________2.
2. Radial cell not exceeding second cubital cell, or at most only slightly; punctures on pronotum dense, coalescing in places.
(27) (Chosen) **bicarinata** Cameron.
Radial cell greatly exceeding the second cubital cell; punctures on pronotum sparse and well separated__________(29) (China) **cilicincta**, new species.
3. First tergite without a deep preapical groove overlapped at its middle, at most with an impressed preapical band of punctures; no dense, short, erect, brown pile on dorsum of abdomen_____________________________6.
First tergite with a deep preapical groove broadly overlapped at its middle; dense, short, erect, brown pile dorsally on segments 3 to 5___________4.
4. Sternites 2 to 5 clothed apically with dense, erect, brown pile; third antennal segment reddish___________________(8) (China) **communis, new species.**
Sternites devoid of dense, erect, brown pile on their apices_______________5.
5. Sixth tergite with the short, erect, brown spinules at most scarcely more numerous than the long, irregular, yellowish hairs; the brown spinules not present on the vertical sides of the intermediate tergites.
(2) (Chosen) **ovidorsalis**, new species.
Sixth tergite with the short, erect, brown spinules at least as numerous as the long, irregular, yellowish hairs; the brown spinules densely distributed on the vertical sides of the intermediate tergites as far as the lateral margins___________________________(3) (China) **antigenata**, new species.
6. Fifth sternite without an orifice beneath the inner edge of the denticle___9.
Fifth sternite with a deep orifice beneath the inner edge of the denticle__7.
7. Radial cell at most only slightly exceeding the second cubital cell______8.
Radial cell greatly exceeding second cubital cell.
(11) (China) **singularis**, new species.
8. Denticle of fifth sternite unusually large; tergites lacking apical row of vestigial punctures behind the row of large, setigerous apical primary punctures; metathorax densely beset with coarse punctures nearly equaling the largest of the scutellum; a very large species.
(10) (Chosen) **sternodentata**, new species.
Denticle of fifth sternite of ordinary size; tergites with apical row of vestigial punctures or a linear groove behind the row of large, setigerous apical primary punctures; metathorax partially impunctate, the sparse punctures much smaller than the largest punctures of the scutellum; a small species__________________(13) (China) **rufomandibulata** Smith and
(12) (China, Chosen) **notopolita**, new species.

9. Lower front masked with abundant, long, appressed, white hair which is more strongly directed laterally than posteriorly on lower half of front; flagellum mostly fulvous_____________(17) (India) **capillata**, new species.
Lower front not masked; hairs, when long, are sparse, erect, and scarcely visible when viewed from in front, or, if appressed, very short, and usually directed more strongly posteriorly than laterally; flagellum usually wholly black____10.
10. Mesepisternum bipunctate over the entire upper half, the minute punctures everywhere within this area at least as numerous as the primary punctures____18.
Mesepisternum with the extreme outer, convex surface of the upper half at most only sparsely bipunctate, the minute punctures on this region much less numerous than the primary punctures____________________11.
11. Radial cell exceeding second cubital cell___________________________________13.
Radial cell at most only equaling second cubital cell____________________12.
12. Segments 2 to 6 of the abdomen with apical rows of brownish hairs well differentiated from the coarse, sparse, white hairs; a large species.
(27) (Chosen) **bicarinata** Cameron.
Segments 2 to 6 of the abdomen without apical rows of coarse, brownish hairs; mesepisternum with punctures not clearly outlined; a small species_____________________________(35) (India) **pullivora**, new species.
13. Tegula not distinctly longer than broad__________________________________14.
Tegula twice as long as broad____(39) (China) **longitegulata**, new species.
14. Upper portion of the sides of the propodeum strongly rugose, and sharply defined from the nonrugose lower portion; punctures of the second tergite moderately large____15.
Upper portion of the sides of propodeum almost devoid of rugae, and not sharply defined from the lower portion; punctures of the second tergite extremely small, scarcely visible________(42) (China) **nana**, new species.
15. Impunctate medial stripe on sixth sternite linear, or slightly wider anteriorly; tergites strongly shagreened__________________________________16.
Impunctate medial stripe on sixth sternite wedge-shaped, with its apex directed cephalad; tergites at most very faintly shagreened.
(33) (Chosen, China) **vernalis** Rohwer.
16. Intermediate abdominal segments without apical ciliate belts of coarse hairs; first cubital mark not present________________________________17.
Intermediate abdominal segments each with apical belts of very coarse cilia clearly differentiated from the ordinary, irregular hairs; first cubital mark clearly defined______________________(30) (China) **fukiensis**, new species.
17. Legs mostly ferruginous; preocellar area broad, with impunctate interspaces broader than an ocellus; tergites with the impunctate apices scarcely wider than the largest adjacent primary punctures.
(24) (Chosen, China) **malayana** Cameron.
Legs black; preocellar area limited without impunctate interspaces as broad as an ocellus; tergites with impunctate apices at least four times the width of largest adjacent primary punctures.
(34) (India) **matura**, new species.
18. Dense secondary punctures of sides of front confined to lowest third, if present____19.
Dense secondary punctures on sides of front extending upward over lower two-thirds of front____(19) (Japan, Chosen, China) **popilliavora** Rohwer.

19. Clypeoantennal distance scarcely greater than the width of clypeal extension at its apex--20.
Clypeoantennal distance twice as great as the width of the clypeal extension at its apex------------(20) (Chosen, China) **phyllophagae, new species.**
20. Pronotum not shagreened--21.
Pronotum conspicuously shagreened-----(35) (India) **pullivora, new species.**
21. Apical half of first sternite without dense, minute punctures------------22.
Apical half of first sternite with dense, minute punctures.
(36) (Japan) **biseculata, new species.**
22. Front with its secondary punctures not extending medially above lower half; antennocular distance equal to or greater than width of antennal fossa--23.
Front with moderate number of secondary punctures extending medially nearly to lowest ocellus; antennocular distance distinctly less than width of antennal fossa--------------------(34) (India) **matura, new species.**
23. Denticle on sixth sternite of usual size, its elevated edge more than half as long as the median width of the punctate portion of the sternite; tegula bright red, thin and semitransparent--------------------------------24.
Denticle on sixth sternite very small, its elevated edge not half as long as the median width of the punctate portion of the sternite; tegula more or less castaneous, thick, and opaqe; secondary punctures of mesepisternum everywhere well differentiated from the much larger primaries, and much more numerous-----------------(22) (China) **inconspicua, new species.**
24. Preapical band of the first tergite laterally with its dorsal punctures separated from each other by interspaces wider than width of punctures, and somewhat distinct from the rather shallowly impressed anterior portion of the band--------------------(32) (Japan, Chosen) **agilis Smith.**
Preapical band of first tergite laterally with its dorsal punctures separated from each other by interspaces narrower than width of punctures, and extensively coalesced with the deep, narrow, medial, impressed portion of the band--------------------------(31) (Chosen) **asericae, new species.**

1. TIPHIA KOREANA Rohwer

Tiphia koreana Rohwer, Proc. Ent. Soc. Wash., vol. 29, p. 19, 1927.—Clausen, King, and Teranishi, U. S. Dept. Agr. Dept. Bull. 1429, p. 42, 1927.

The following supplementary notes may be helpful in fixing this recently described species among those discussed in this paper. Female with primary punctures on vertex more sparse medially than on either side. Clypeus with its lateral margin strongly convex Third joint of antenna distinctly longer than broad. Metanotum with a minutely punctate apical callosity, elsewhere with coarse punctures nearly as large as those of the scutellum. Mesepisternum with a well-developed marginal groove on its posterior slope. First tergite with its dorsal punctures dimpled; with a deep preapical groove overlapped at the middle. First sternite with a crenulate median groove; lateral groove on posterior half. Tergites 3 to 5 with conspicuous bands of dense, short, reddish pile, well differentiated from the long, sparse, white hairs, and extending to the lateral

margins of the tergites. Pygidium without a median impunctate emargination of the punctate upper portion. The male is not known.

Distribution.—Keikido, Chosen.

In the collection of the Japanese Beetle Laboratory are to be found the following: Two females, Suigen, Chosen, August 1 and 2, 1925 (Sato), Gardner No. 2, and 3 females, Suigen, Chosen, July, 1926 (Gardner), Gardner No. 2. Single specimens from the same lots have been deposited in the British Museum and in the collections of the Illinois Natural History Survey and the Philadelphia Academy of Natural Sciences.

2. TIPHIA OVIDORSALIS, new species

Female.—Vertex with primary punctures of first-degree density in limited areas between and just behind the ocelli and near the upper orbits of the inner eye, elsewhere of third-degree, with irregular impunctate spaces. Front faintly shagreened below, with impunctate stripe and groove; primary punctures of lower front scarcely more dense medially than toward either eye, of first-degree density just above base of antennae, along the impunctate stripe to lowest ocellus, and along orbits of inner eye, with a vague, trident-shaped area where primary punctures are lacking or of second-degree density. Clypeus with its lateral margin strongly convex; extension with impunctate apex limited above by coarse punctures not in a regular transverse row. Antenna with its third joint distinctly longer than its greatest width. Pronotum sometimes faintly shagreened, with the transverse carina complete but low across the dorsum; primary punctures in a vaguely defined transverse discal band, scarcely less dense on lateral disks than medially, largely of second-degree density; secondary punctures sparsely scattered on anterior half; punctate area medially of greater longitudinal extension than the impunctate. Side of pronotum with a groove in the center about one-fourth the length of the sclerite, preceded by several short gouges or round punctures. Mesepisternum with a well-developed premarginal crease or groove along its posterior border. Metathorax with a minutely punctate apical callosity, and on either side with coarse primary punctures which are nearly as large as those of the scutellum. Legs with the major calcarium of the hind tibia usually tapering from the base; hind basitarsus with one or two prickle-shaped spines on the outside, but none of the same type at the apex. Tegula with a narrow, abruptly thickened posterior margin. Wings very smoky. Propodeal areola keystone-shaped, one and two-thirds to two times as long as wide; lateral carina bordered on outside by interrupted grooves; medial carina tapering

from a broad base to its apex, one-half to two-thirds the distance to posterior margin; inclosed area faintly shagreened. Dorsal aspect of propodeum outside of areola with sparse, round primary punctures. Lower portion of sides of propodeum polished and minutely setulo-punctate on posterior half. Posterior aspect of propodeum with a few shallow punctures on upper disk; carina on lowest fourth or less. Fourth tergite without preapical band, but with a deep preapical groove broadly overlapped at the middle, though not to the extent of covering the dorso-medial apex; primary punctures dimpled dorsally; a row of minute punctures visible on dorsum just behind the edge of the folded groove. First sternite with a lateral groove on posterior half, and with shallow punctures anteriorly. Tergites 2 to 5 with marginal incised lines; tergites 3 and 4 dorsally with dense secondary punctures, from which arise stiff, short, erect, brown hairs best seen in profile and entirely lacking on the sides. Pygidium sparsely reticulo-punctate, sometimes faintly carniate; impunctate emargination small; apical impunctate portion longitudinally wrinkled and plainly shagreened; sting sheaths and palps not protruding while in repose. Length, 8 mm.

Male.—Clearly resembles the male of *antigenata* from which it differs in the following characters. Vertex with primary punctures back of ocelli largely of third-degree density, usually sparsely beset with minute punctures. Front with poorly defined medial impunctate stripe and vestigial groove; preocellar region of front with sparse primary punctures of second and third degree density, with several interspaces as broad as an ocellus. Primary punctures of pronotum largely of third-degree density, with slight tendency toward series of second degree. First tergite with its preapical fold terminating well before the apex of the segment, well flattened apically, and followed by a row of very small punctures not covered by the fold at any point on dorsum; dimpled punctures separated from apex of fold by at least several times their average diameters. Impunctate margins of intermediate tergites at most three times as wide as adjacent primary punctures. Length 5 to 6 mm.

Distribution.—Keikido, Chosen.

Type and allotype.—Cat. No. 41774, U.S.N.M. Type, female, Suigen, Chosen, August 18, 1925 (Sato), Gardner No. 10. Allotype, male, Suigen, Chosen, Jap. Beetle Par. Exp. 318.

Paratypes.—All from Suigen, Chosen. In the United States National Museum: One female, August 3, 1925 (Sato); 1 female August 23, 1925 (Sato); 3 females, August, 1926 (Gardner), all labeled "Gardner No. 10"; 1 female, no date; 4 females, Jap. Beetle Par. Exp. 318. In the collection of the Japanese Beetle Laboratory: One female, August 26, Gardner No. 10, and 1 male, Jap. Beetle Par.

Exp. 318. Deposited in the British Museum: One female, August 4, 1925 (Sato), Gardner No. 10, and 1 male, Jap. Beetle Par. Exp. 318. Deposited in the collection of the Illinois Natural History Survey: One female, Jap. Beetle Par. Exp. 318. Deposited in the collection of the Philadelphia Academy of Natural Sciences: One female, August, 1926 (Gardner), Gardner No. 10.

Those specimens bearing label "Jap. Beetle Par. Exp. 318" (Japanese Beetle Parasite Experiment 318) were reared from females collected in Chosen, the males thus obtained being from known females.

The species *ovidorsalis*, *koreana*, and *antigenata* are the only ones as yet studied in which the very characteristic erect brown pile has been found in the female. *Ovidorsalis* differs from *koreana* in having the brown pile confined to the dorsal part of the tergite, and from *antigenata* in having the premarginal groove of the first tergite less strongly overlapped, with fine punctures visible behind the edge of the fold. In specimens used in breeding work at Suigen, Chosen, in August, 1926, the premarginal groove of the mesepisternum is reduced to a hair-fine crease or is even lacking altogether. One female of this lot which has no fine, erect brown pile on the dorsum is referred to this species because of information obtained from biological studies and because the conformation of the first tergite is typical of the species.

3. TIPHIA ANTIGENATA, new species

Female.—Vertex with primary punctures of first degree density everywhere except in limited areas on either side of postocellar patch. Front polished; groove vaguely defined; primary punctures densely and irregularly distributed, their outlines elongated toward ocelli; medially on anterior half the combined area of primary punctures exceeds that of their interspaces, but laterally from this place they become much sparser, everywhere of first degree density except on vaguely trident-shaped area below ocellar triangle. Clypeus with its lateral margin slightly convex; extension with its apex impunctate except for minute punctures; impunctate area defined by coarse punctures, not limited by regular transverse row, its longitudinal extension equal to about one-fourth the distance from apex to base of antennae. Antenna with its third joint distinctly longer than broad. Pronotum with the transverse carina complete and strongly developed; primary punctures well differentiated from the secondaries, evenly distributed, mostly of first-degree density, with no distinct transverse discal band; secondary punctures include a very few punctures in the anterio-medial area; longitudinal extension of the punctate area medially about equal to that of the im-

punctate area. Side of pronotum with numerous punctures along the anterior borders and in a small depressed patch medially in front of the tegula. Mesepisternum with a well defined premarginal groove on its posterior slope. Metanotum with apical callosity more or less densely beset with minute punctures, the largest somewhat smaller than those of the scutellum. Legs with major calcarium of hind tibia uniformly tapering; hind basitarsus without a groove, a group of two pricklelike spines on outside beyond middle but none at apex. Tegula without impressed line on the outside but with a short, incised line on lower inner margin. Wings moderately smoky. Propodeal areola convergent, keystone-shaped, twice as long as wide; lateral carinae with a bordering groove on the outside; median carina broadening anteriorly, two-thirds the length of areola. Lower portion of sides of propodeum polished, posterior half densely setulo-punctate. Posterior aspect of propodeum with a few scattered punctures on the upper margin; median carina developed on less than lower half. First tergite with dorsal punctures dimpled, without a preapical band, but with a deep preapical groove broadly overlapped dorsally. First sternite vaguely rugose, but lacking definite primary punctures; lateral grooves on posterior half. Tergites 3, 4, and 5 with well defined marginal incised line, tergites 3 and 4 with dense secondary punctures on basal half, but lacking erect, brown hairs. Pygidium not carinate, sparsely and irregularly punctate, without well-defined impunctate emargination of punctate basal portion; impunctate apex with many wrinkles converging below, and strongly shagreened. Length, 9.5 mm.

Male.—Vertex with primary punctures back of ocelli of first degree density. Front with primary punctures moderately large, of first-degree density medially below middle and laterally to vertex, of uniform second-degree density in preocellar region; primary punctures displaced almost completely on lower third by dense secondary punctures which extend upward in the interspaces as far laterally as medially, about half way to lowest ocellus. Antennocular distance much greater than width of antennal fossa. Clypeal extension with its apical width four-fifths the clypeo-antennal distance; apex shallowly emarginate without inpunctuate margin. Flagellum with a narrow fuscous stripe beneath. Pronotum with primary punctures large, deep, round, of first-degree density, and evenly distributed; a few widely scattered secondary punctures. Side of pronotum with a series of overlapping rugae extending from ventral corner one-third to three-fourths distance to alar angle; primary punctures extending down from dorsum along entire length of the plate. Mesepisterum with moderately large, round, primary punctures of vague outline, mostly of second-degree density; secon-

dary punctures usually less numerous than primaries except on posterior slope, sparse on upper disk, almost lacking ventrally, a deep groove or abruptly impressed line of demarcation extending along the posterior border to the spiracle. Scutellum variable. Metanotum with apical callosity; primary punctures of first-degree density and nearly as large as those of the scutellum. Wings with the radial cell equalling the third cubital cell. Propodeum with the areola keystone-shaped, about one and one-fourth to one and one-half times as long as wide, carinae highest and thickest at apex of areola, median carina usually confined to upper half of areola, interspaces flat and polished; dorsum outside areola with sparse primary punctures; posterior aspect finely setulose and densely rugose-punctate without round primary punctures, with a median carina on lower half or less. First tergite beset with large, dimpled primary punctures, those at the apex usually separated from edge of fold by a distance not greatly exceeding the average diameter of primary punctures; without preapical band, but with a deep preapical overlapped groove thickened apically and largely concealing a row of vestigial apical punctures. First sternite vaguely punctate, anteriorly without a definite median keel; apical fossa crenulate; lateral grooves on lower third or less. Tergites 3 to 5 with dense, erect, short, brown pile extending in abundance to lateral edges of tergites; tergite 6 somewhat less densely brown-setulose; no impunctate margin at apex of segments; marginal incised line complete over the dorsum. Sternites with the usual whitish pile but lacking the dense, erect, short, brown pile found on the dorsum. Length, 7 to 8 mm.

Distribution.—Kiangsu, China.

Type and allotype.—Cat. No. 41775, U.S.N.M. Type, female, and allotype, male, Penniu, China, Insectary Reared No. 205.

Paratypes.—Retained in the collection of the Japanese Beetle Laboratory: One male and one female, Penniu, China, Insectary Reared No. 205. Deposited in the collection of the British Museum: One female, Kuliang, China, August 16, 1926 (Jen), and 1 male, Penniu, China, Insectary Reared No. 205. Deposited in the collection of the Illinois Natural History Survey: One female, Kuliang, China, August 16, 1926 (Jen), and 1 male, Kuliang, China, 1926 (Jen). Deposited in the colletion of the Philadelphia Academy of Natural Sciences: One female, Kuliang, China, August 16, 1926 (Jen), and 1 male, Kuliang, China, 1926 (Jen). Deposited in the U. S. National Museum: One male, 6C-1, emerged June 5, 1926, and 3 males, Kuliang, China, 1926 (Jen).

The specimens labelled "Insectary Reared No. 205" were the progeny of females collected in China. In the rearing work, the females of this species were not completely segregated from *communis*

and *popilliavora*, but the biological and anatomical characters were sufficiently different to permit of subsequent segregation and to insure the association of males and females with a reasonable degree of certainty.

4. TIPHIA ASSAMENSIS, new species

Female.—Vertex densely punctate with elongated punctures which vary irregularly from first to second-degree density, but which are densest between ocelli and at the upper inner corners of the eyes; a few minute punctures on dorso-medial line extending nearly to ocellar triangle. Front shagreened below, with pronounced impunctate stripe and groove; primary punctures large and elongated upward, everywhere of first-degree density save in limited areas around lowest ocellus where they are of second-degree density, about equally distributed between the eyes below. Clypeus with convex lateral margin; extension with its margin impunctate save for scattered, minute punctures, longitudinal extension one-third distance front apex of clypeus to base of antenna. Antenna with third joint distinctly longer than greatest width. Pronotum with its carina complete and very sharply erect; primary punctures large and elongated, everywhere of first-degree density, without trace of discal band or of sparseness on lateral disks; secondary punctures lacking; longitudinal extension of punctate area medially less than the impunctate area. Side of pronotum with the usual ventral striations becoming deeper near center, but not developed as an unbroken groove for as much as half the length of sclerite. Mesepisternum with a well defined premarginal groove on the posterior slope. Metasternum with an impunctate apical callosity and numerous coarse primary punctures nearly as large as the primary punctures of the scutellum. Legs with the major calcarium of the hind tibia tapering from the base, without a sharp bend near the middle; hind basitarsus on outside with row of two spines terminating before the apex. Tegula without line on the lateral margin, but with a shallow, incised line on posterior margin. Propodeal areola hastate, strongly convergent, one and one-half times as long as wide; lateral carinae with interrupted bordering grooves on the outside anteriorly; medial carina developed on the upper half or less; enclosed area unusually flat and highly polished. Lower portion of sides of propodeum with minute, setulose punctures on lower half. Posterior aspect of propodeum densely hairy, with scattered punctures on upper disk; carina sharply elevated on lower half or less. First tergite without preapical band, but with deep preapical groove broadly overlapped at the middle, and with dimpled punctures on the dorsum. First sternite occasionally with a prominent, crenulate medial groove; lateral grooves on posterior fourth; disk faintly and wavily wrinkled.

Tergites 3 and 4 with dense secondary punctures which merge with the sparse primary punctures apically; impunctate margins at center at least three times the width of adjacent primary punctures, laterally with deep, incised marginal lines which become faint rows of very minute vestigial punctures over the dorsum on these two segments. Pygidium on basal half coarsely rugose, without impunctate emargination of the punctate base; apical impunctate section vaguely carinate, with pronounced wrinkles and shagreening; stylet and sting palps not prominently protruding. Length 8 to 10 mm.

Male.—Not known.

Distribution.—Assam, India.

Type.—Cat. No. 41776, U.S.N.M. Female, Shillong, India, May, 1927 (Clausen). Clausen No. 2056.

Single females of the same lot as the type have been deposited in the collections of the British Museum, the Illinois Natural History Survey, and the Philadelphia Academy of Natural Sciences. The remaining eight specimens, also labeled like the type, are retained in the collection of the Japanese Beetle Laboratory.

The female of this species differs from the female of the closely related *antigenata* in having a dorso-medial row of minute punctures on the vertex, in having the width of the apex of the propodeal areola less than half the greatest width of the areola, and in having a shorter, narrower medial carina in the propodeal enclosure. Unfortunately, this species is represented by a small series of more or less fungus-covered specimens, in which the best specimen by far is atypical in having a wider, longer medial carina in the propodeal areola, a carina on the lower half of the posterior aspect of the propodeum, and a crenulate median groove on the first sternite.

5. TIPHIA TEGITIPLAGA, new species

Female.—Vertex with primary punctures of first-degree density between and on either side of ocelli, of third-degree density back of ocelli, and still sparser on either side. Front polished, with interrupted groove; primary punctures becoming shallower above, rather regularly distributed, except that they are somewhat denser on the lower half where they are slightly more closely grouped medially, everywhere of first-degree density except in a vaguely defined area bordering the ocellar triangle below. Clypeus with its margin slightly convex; apex not entirely impunctate, the punctures extending irregularly almost to apical margin. Antenna with third joint distinctly longer than its greatest width. Pronotum with its transverse carina completely and strongly developed; primary punctures mostly of first-degree density, evenly distributed, with no transverse discal band; secondary punctures almost lacking; longitudinal extension of the punctate area medially slightly less than the impunc-

tate. Side of pronotum with more or less distinctly separated punctures in a band posterior to carina and narrowly along dorsal border. Scutum with its notauli and anterior medial groove continuous or nearly so and its punctures evenly distributed. Mesepisternum with a well-developed premarginal groove on its posterior slope. Metanotum with a vestigial apical callosity, elsewhere densely and coarsely punctate, the primary punctures scarcely smaller than those of the scutellum. Legs with major calcarium of hind tibia uniformly tapering; hind basitarsus on the outside with a series of two lanceolate spines, but none of the same type at the apex. Tegula with the inner hind angle somewhat produced and upcurled, with densely pilose hairs. Wings moderately smoky. Propodeal areola hastate, strongly convergent, twice as long as wide; carinae low, bordered by irregular grooves; median carina much wider anteriorly and not quite complete. Lower portion of sides of propodeum polished, striate, posterior third minutely setulo-punctate. Posterior aspect of propodeum densely reticulo-punctate; median carina developed on lowest fourth. First tergite with its larger punctures dimpled; without preapical band, but with a deep preapical groove overlapped at the middle. First sternite flat and polished, with a shallow median groove crossed by short, transverse ridges, and a lateral groove on the posterior half; with scattered, shallow punctures on the anterior half. Tergites 2, 3, and 4 with marginal incised lines but lacking areas of dense secondary punctures or very short, erect, brown pile. Pygidium coarsely reticulo-punctate on basal three-fifths; without a well differentiated impunctate emargination of the punctate base; apex faintly shagreened below the punctures and longitudinally wrinkled at the sides. Length, 10.5 mm.

Distribution.—Shizuoka, Kanagawa, Japan.

Type.—Cat. No. 41777, U.S.N.M. Female, Miho, Japan, October 1, 1926.

Paratypes.—In the collection of the Japanese Beetle Laboratory: One female, Miho, Japan, October 1, 1926. Deposited with the British Museum: One female, Miho, Japan, October 1, 1926. Deposited in the United States National Museum: One female, Yokohama, Japan, July 17, 1920 (Clausen), Clausen No. 1382.

One male from Morioka, Japan, August 20, 1920 (Clausen), in the United States National Museum belongs in the *koreana* group, and may be the male of this species.

6. TIPHIA AUTUMNALIS Rohwer

Tiphia autumnalis ROHWER, Proc. Ent. Soc. Wash., vol. 26, p. 88, 1924

The following notes supplementary to the original description will aid in fixing the species. Vertex with small patches of punctures of

first-degree density between and on either side of the ocelli, those immediately behind the triangle rather sparse and irregular, and not more dense than on either side. Lateral margin of clypeus convex. Third antennal joint longer than greatest width. Metathorax with vestigial apical callosity, its punctures coarse and at least half as large as the largest on the scutellum. Propodeal areola hastate in outline, two and one-fourth times as long as its greatest width. First tergite with a deep preapical groove broadly overlapped on the dorsum and with dimpled punctures. First sternite with a wide, polished, impunctate median stripe flanked by dense, minute punctures and sparse, round primary punctures; lateral groove obsolete. Tergites two to four without large patches of dense secondary punctures or of erect, short, brown pile; with strong premarginal grooves over the dorsum.

Male.—Not known.

Distribution.—Keikido, Chosen; Iwate, Japan.

Deposited in the collection of the British Museum: One additional specimen from Kowai, Japan, August, 1926.

This species is referred to by Mr. Clausen under his number 1385.

7. TIPHIA FOSSATA, new species

Plate 1, fig. 1

Female.—Vertex with primary punctures scarcely denser medially than on either side, everywhere of second-degree or third-degree density except small patches near upper portion of eyes and between ocelli. Front polished; primary punctures densely and irregularly distributed; medially, on anterior half, the combined area of primary punctures exceeding that of their interspaces, but from this place becoming scattered and of second-degree and third-degree density. Clypeus with its lateral margin slightly convex; apex impunctate for one-fourth the distance to base of antennae, except for extremely minute punctures. Antenna with the third joint distinctly longer than broad. Pronotum with its transverse carina strongly developed except for a narrow gap in the middle; primary punctures very well differentiated from the secondary punctures, densely and evenly distributed over the whole punctate area, no transverse discal band; secondary punctures sparse and confined to anterior median area; a narrow but distinct median impunctate stripe; the median longitudinal extension of the punctate area distinctly greater than that of the impunctate area. Side of pronotum with upper surface polished, striate, with numerous well separated, round punctures along the upper border. Mesepisternum with a strong premarginal groove on its posterior slope. Metanotum densely double-punctate, punctures

as large as those of the scutellum. Legs with major calcarium of hind tibia uniformly tapering; hind basitarsus with a group of 3 to 5 small, pricklelike spines on outside near middle, no similar ones at apex. Tegula with inner hind corner slightly produced and upcurled, densely hairy. Wings moderately smoky. Propodeal areola hastate, strongly convergent, from two to two and one-half times as long as wide, apex one-third as wide as greatest basal width; lateral carinae not well defined externally; median carina lacking; enclosed area strongly arched and very irregularly punctate. Lower portion of sides of propodeum polished, striate, posterior half densely setulo-punctate. Posterior aspect of propodeum with a few scattered punctures anterio-medially, no median carina. First tergite with the larger dorsal punctures dimpled; deep preapical groove overlapped at center; lacking a preapical band. First sternite with polished, shallow medial groove; disk on either side with shallow, irregular primary punctures; no lateral groove. Intermediate abdominal segments with tergites 2, 3, and 4 bearing very strong preapical incised lines; tergites 3 and 4 with dense secondary punctures clearly differentiated from the large primary punctures, and without short, erect, brown hairs differentiated from the usual pale hairs. Pygidium coarsely reticulo-punctate on basal three-fifths, apex longitudinally wrinkled near punctures and transversely at the margin. Length, 15 mm.

Male.—Not known.

Distribution.—Keikido, Chosen.

Type.—Female, Cat. No. 41778, U.S.N.M., Suigen, Chosen, August, 1926. (T. R. G.) Gardner No. 14.

Paratype.—Female, of same date, locality, and number, retained in collection of the Japanese Beetle Laboratory.

This species very closely resembles *autumnalis*, from which it differs in having the secondary punctures on dorsa of the tergites denser and extending over a much wider area. Specimens of this species were mixed with the very different *totopunctata* in the lot under Gardner's note No. 14.

8. TIPHIA COMMUNIS, new species

Plate 1, figs. 4, 8; plate 2, figs. 13, 15; plate 3, figs. 18, 23; plate 4, fig. 26

Female.—Vertex with primary punctures of first-degree density between ocelli, and irregularly between eyes and ocellar triangle, elsewhere mostly of third-degree density, and not denser medially than on either side. Front shagreened on lower half; carina rather broadly conical, impunctate stripe narrow but well marked, groove well defined; primary punctures very large and of first-degree density

nearly everywhere except irregularly between ocelli and lower orbits, on lower half more densely grouped medially than near the eyes. Clypeus with its lateral margin strongly convex; extension with its apex impunctate except for minute punctures, the impunctate apex defined by coarse punctures which are not in a regular, transverse row, the longitudinal extension of the impunctate apex equal to two-fifths the distance from apex of clypeus to base of antennae. Antenna with its first joint slightly angulate apico-ventrally; third joint longer than its greatest width. Pronotum with its transverse carina completely and strongly developed; primary punctures of first-degree density over whole anterior dorsum, with no transverse discal band; secondary punctures almost lacking; median width of punctate area exceeding that of impunctate. Side of pronotum with a series of very irregular, short, interrupted grooves and punctures extending in a tapering series across the center; punctures distinct along the dorsal border, coalescing in a depressed patch just before the tegulae. Scutum with its notauli and its anterior medial groove continuous. Metanotum with a medio-apical callosity, punctures nearly as coarse as those of the scutellum. Legs with major calcarium of hind tibia tapering from base; hind basitarsus on the outside with a row of three pricklelike spines terminating before apex. Tegula with inner hind angle produced and upcurled, bearing dense yellow pile with some longer, suberect hairs. Wings very smoky, with first cubital mark not well defined. Propodeal areola hastate, twice as long as wide; outside carinae bordered with interrupted grooves; median carina usually irregularly broadened, with polished surface anteriorly, usually confined to upper three-fifths, with reticulate connections posteriorly; enclosed areas outside the reticulations smooth. Lower portion of side of propodeum with its anterior portion highly polished, posterior half with dense patch of conspicuous setigerous punctures. Posterior aspect of propodeum coarsely but shallowly punctate over all its surface; median carina strongly developed on lower half or less. First abdominal tergite dorsally with dimpled primary punctures, no preapical band, but a deep preapical groove, overlapped except at sides. First sternite with a median groove broken by transverse ridges; lateral grooves on posterior half or less; shallow punctures widely distributed over disk. Tergites 2, 3, and 4 with pronounced marginal incised lines but without dense patches of secondary punctures or any short, brown pile; no impunctate margins. Pygidium coarsely reticulo-punctate on basal three-fifths, usually without well-defined impunctate emargination of the punctate base, but with a low median carina extending the full length of the segment, apex anteriorly shagreened and strongly wrinkled. Length, 11.5 to 14.5 mm.

Male.—Vertex with primary punctures back of ocelli of first-degree density. Front shagreened on lower half; impunctate stripe and carina frequently present; primary punctures large, uniformly distributed over upper two-thirds, of first-degree density except for a limited preocellar area of second-degree density; secondary punctures more numerous than primary punctures on lower third, extending upward one-half distance to lowest ocellus laterally, not so high medially. Antennocular distance greater than width of antennal fossa. Clypeal extension with its width eight-ninths the clypeo-antennal distance; apex very shallowly emarginate, with a very narrow impunctate margin. Antenna with the third joint distinguished from the others by a reddish color. Pronotum with punctures large, deep, evenly spaced, mostly of first-degree density with a tendency to second degree; secondary punctures lacking. Side of pronotum frequently with an irregular, tapering groove or series of grooves, separated by diagonal rugae extending partially across the center. Mesepisternum with large, round, sharply outlined primary punctures, mostly of first-degree density; secondary punctures very well differentiated and on all parts of upper disk much more numerous than the primary punctures; posterior border elevated, though usually devoid of a true premarginal groove. Scutellum without impunctate apex as wide as the largest apical primary punctures. Metanotum with apical callosity; primary punctures nearly as large as those of the scutellum, and more than equaling the area of their interspaces. Tegula shagreened, with inner corner more than usually produced and upcurled, commonly with a posterior marginal impression ending abruptly at the outer hind corner. Wings with radial cell not equaling second cubital cell in apical extension. Propodeum with areola one and one-half times as long as wide, with sharply converging sides, areolar carinae becoming much higher posteriorly, median carina present on anterior half at most, frequently lacking, enclosed area flat and polished posteriorly; lower portion of sides faintly shagreened anteriorly, posterior portion minutely setulo-punctate; posterior aspect with a few large, vague punctures at the sides, its median carina present on lower half or less. First tergite with the large, dorsal primary punctures dimpled, no preapical band, but with a deep, preapical, overlapped groove. First sternite with its disk usually transversely wrinkled, the apical fossa crenulate; lateral grooves present on posterior half or less; a crenulate groove more or less clearly developed along the medial line; anteriorly without a well-defined keel. Tergites 3 to 5 with dense, short, erect, brown pile; punctures removed from the apex at most by about three times width of largest adjacent primary punctures; marginal grooved line developed over the dorsum on segments 2 to 5;

segment 6 with distinctly coarser punctures. Sternites with a narrow apical fringe of pile similar to that of the tergites. Genitalia in ventral aspect with the outer clasper elongate-lobate, gradually tapering toward its base; second genital segment with apical hook tapering abruptly to a sharp point and the inner hind margin broadly convex, but not angulate; distal portion of aedeagus with its apical lobes tapering to sharp, laterally-directed points, lateral processes somewhat broader than apical lobes; proximal portion of aedeagus with broad shoulders near the constriction. Length, 7 to 11 mm.

Distribution.—Chekiang, Kiangsu, and Fukien, China.

Type and allotype.—Cat. No. 41779, U.S.N.M. Type, female, Hangchow, China, September 19, 1924 (Chao), Exp. N4. Allotype, male, Hangchow, China, July, 1925 (Jaynes).

Paratypes.—Retained in the collection of the Japanese Beetle Laboratory: Four females and 2 males, Hangchow, China, July, 1925 (Jaynes). Deposited in the collections of the British Museum, the Illinois Natural History Survey, and the Philadelphia Academy of Natural Sciences: Four females and 2 males to each, from the same lot as the above. Deposited with the United States National Museum: From Hangchow, China, 1 male, July 20, 1924; 10 males, August 31, 1924 (Jaynes); 1 male, August 31, 1924 (Illingworth); 11 males, September 4 to 22, 1924 (Illingworth); 1 male September 4, 1924, 1 male, September 16, 1924; 2 males, September 18, 1924; 28 females, September 19 to October 21, 1924 (Chao); 2 males, September 21, 1924; 1 male, October 2, 1924; 1 female, June 19, 1925 (Chao); 166 females and 81 males, July, 1925 (Jaynes); 3 females, July 6, 1925 (Chao); 21 females and 4 males, July 7, 1925 (Chao); 3 males, July 8, 1925 (Chao); 1 male, July 20, 1925 (Chao); 17 females, September 9 and 10, 1925 (Chao); 20 females, June 17 to 21, 1926 (Chao); and 5 males, June 19 and 20, 1926 (Chao). From Nanking, China, 1 male, September 30, 1924 (Jaynes). From Chinkiang, China, 1 female, July 12, 1924, Exp. A (Jaynes) Rohwer No. 12; 1 female and 1 male, July 26, 1924 (Illingworth) (Jaynes); 1 female, July 30, 1924; 1 female, August 13, 1924, Exp. 73 (Jaynes), Rohwer No. 12; 11 males, August 8 to 26, 1924 (Jaynes); 1 male, August 11, 1924; 1 female, July 5, 1925 (Wong); 5 females, 1925; 29 females (18 numbered) and 5 males. From Yangchow, China, 3 males, August 7 to 15, 1924 (Wong); 1 female, August 15, 1924 (Wong); 1 male, August 24, 1924; 2 males, August 24, 1924, Jaynes Nos. 92 and 94; from Penniu, China, 1 female, June 24, 1925 (Wong); 1 female, September 21, 1925 (Wong); 1 female, September 23, 1925 (Wong); 2 females, September 29, 1925 (Wong); 1 female, October 5, 1925

(Wong); 1 female, October 6, 1925 (Wong); 20 females, 1925 (Wong); 3 females, Riverton Exp. 207; 2 females, July 14 and 18, 1926 (Shien); 3 males, Riverton Exp. 207, August 9, 1926 (Jaynes); 1 male, Riverton Exp. 207, August 14, 1926 (Jaynes); 1 male, Riverton Exp. 224, August 19, 1926 (Jaynes); 8 males and 9 females, Riverton Exp. 205 insectary reared; 1 male, Riverton Exp. 207 insectary reared (Jaynes); 5 females reared from cocoons, 6 females, 1926, Jaynes No. 109 (Wong); 1 female, Riverton Exp. 307B, July 17, 1927, and 1 male, Riverton Exp. 307, July 1927. From Ningpo, China, 1 female, June 28, 1925, 1 female, June 29, 1925; 1 female, June 30, 1925; 1 male, June 30, 1925 (Chu); 51 females and 20 males, July 1, 1925 (Jaynes); 3 males, July 2, 1925 (Chu); 3 males, July 4, 1925 (Chu); 8 females, July 4, 1925; 13 females, July 5, 1925; 9 males, July 5, 1925 (Chu); 6 females, July 6, 1925; 5 males, July 6, 1925 (Chu); 2 males, July 7, 1925 (Chu); 1 female, July 8, 1925; 1 female, July 9, 1925; 25 females, July 12, 1925 (Jaynes); 2 females July 12, 1925; 1 female, July 13, 1925; 2 females, July 21, 1925 (Jaynes); 2 females, July 27, 1925 (Jaynes); 16 females, July 28, 1925 (Jaynes); 17 females, July 29, 1925 (Jaynes); 12 females, July 30, 1925 (Jaynes); 4 males, August 25, 1925 (Chu); 3 males, August 29, 1925 (Chu); 2 males, August 30, 1925 (Chu); 1 male, September 1, 1925 (Chu); 4 males, September 2, 1925 (Chu); 37 females, September 10, 1925 (Jaynes); 2 males, emerged August 27 to September 6, 1925, and 2 females, no date. From Kuliang, China, 1 female, July 4, 1925; 2 males and 1 female, August 16 to October 10, 1926 (Jen); 1 male, September 2, 1926; and 2 males, 1926 (Jen); 4 males, no labels.

Thirteen females differ from the type in having the tibiae or the femora or both castaneous to almost bright red. These specimens, which are included among the paratypes deposited in the United States National Museum, are as follows: One, Hangchow, China, September 19, 1924; 2, Penniu, China, 1926 (Wong); 4, insectary reared, Exp. 205; 1, Ningpo, China, July 1, 1925; 2, July 4, 1925; 2, September 10, 1925 (Jaynes); and 1, Chinkiang, China, 1925.

Two of the male paratypes listed from Kuliang, China, differ from the type in having the clypeal extension truncate, thick, and punctate to the apex, and the mesepisternum with secondary punctures distinctly less numerous than the primaries medially along the vertical plane. In one, the third antennal joint is black. These may possibly be of another species, but, for lack of sufficient evidence, they are included here.

This species has been referred to in notes by the junior author under his species number 109.

9. TIPHIA TOTOPUNCTATA, new species

Female.—Vertex with primary punctures not denser medially than on either side, patches of first-degree density on both sides of ocellar triangle, elsewhere of second-degree density with many irregular impunctate areas. Front shagreened or polished, with a rather broad, short carina, a well-differentiated impunctate stripe, and a distinct groove; primary punctures coarse and deep, of first-degree density on lower half from eye to eye, between upper portion of eyes and ocelli, and on either side of vitta, with nearly impunctate spots between ocelli and the eye. Clypeus with its lateral margin slightly convex; extension with its apex impunctate for one-third distance to base of antennae; impunctate margin limited by a series of coarse punctures not arranged in a regular transverse row. Antenna with third joint distinctly longer than its greatest width. Pronotum with primary punctures large and uniformly of first-degree density; transverse discal band not differentiated; secondaries very few in number or absent; medial longitudinal extension of punctate area equal to or slightly greater than that of the impunctate area. Side of pronotum sometimes with a few well-separated punctures just back of the carina; a punctate depression in alar angle. Scutum with its notauli and its anterior medial groove continuous. Metanotum with minutely punctate apical callosity and dense, coarse punctures nearly equalling those of the scutellum. Legs with major calcarium of hind tibia curved but not bent, of equal thickness to middle, then gradually tapering to apex; hind basitarsus with row of three small, pricklelike bristles on outside, terminating far before apex. Tegula faintly shagreened; inner hind corner strongly produced laterally, and densely pilose. Wings smoky, with first cubital mark outlined below by a definite spur from the radius. Propodeal areola variable but usually constricted behind base and again at apex, three times as long as wide; lateral carinae with faint bordering grooves; median carina much interrupted. Lower portion of sides of propodeum faintly striate, the posterior half plainly setulose. Posterior aspect of propodeum smooth except for sparse, round punctures along sides and upper border; median carina usually lacking. First abdominal tergite with its preapical band consisting of a single row of coarse punctures which are sometimes in a slight depression, the band usually interrupted in the center. First sternite flat, with sides laterally expanded near petiole, an unusual amount of dense, appressed hair and sparse, round, widely scattered punctures anteriorly, and no lateral groove. Intermediate tergites with impunctate margin slightly wider at middle, where it is two or three times the width of largest apical primary punctures which are interrupted medially on tergites three and four. Pygidium very coarsely punctate on basal

two-thirds, with an irregular, impunctate, medial emargination of the punctate base elevated and almost carinate; apex strongly wrinkled and shagreened, with a yellowish margin. Length, 14 mm.

Male.—Not known.

Distribution.—Keikido, Chosen; Szechuen, China.

Type.—Cat. No. 41780, U.S.N.M. Type, female, Suigen, Chosen, August, 1926 (Gardner), Gardner No. 14.

Paratypes.—All females. In the National Museum: From Suigen, Chosen, 2, August, 1926 (Gardner), Gardner No. 14; 1, Gardner No. 14, No. 6. From Szechuen, China, 1, 1923 (Graham). Retained in the collection of the Japanese Beetle Laboratory: One, Suigen, Chosen, July 20, 1925 (Sato). In the collection of the Philadelphia Academy of Natural Sciences: One unlabeled specimen. In the British Museum: One, Suigen, Chosen, July 20, 1925 (Sato). To the collection of the Illinois Natural History Survey: One, Suigen, Chosen, August, 1926 (Gardner), Gardner No. 14.

The specimens collected by Gardner were used in breeding work in Chosen. Mixed with this lot, which bears the label Gardner No. 14, were two females of *fossata.*

10. TIPHIA STERNODENTATA, new species

Male.—Vertex with primary punctures of first-degree density between and behind ocelli and near upper orbit of eyes, sparse on either side of medial patch. Front vaguely shagreened; impunctate stripe and groove well developed; primary punctures large, of first-degree density upward from base of antennae to vertex laterally and to lowest ocellus along stripe, with a more sparsely punctate area diagonally below triangle; secondary punctures not apparent. Antennocular distance greater than width of antennal fossa. Clypeal extension with its width four-fifths the clypeoantennal distance; apex shallowly emarginate, with a narrow, impunctate border of uniform width and with a thick edge. Pronotum with punctures very large and shallow, uniformly of first-degree density, but with a tendency to second-degree density on apical half; almost devoid of secondary punctures. Side of pronotum sharply rugosopunctate behind carina, with a tapering series of diagonal rugae across center. Mesepisternum with primary punctures large and clearly outlined, mostly of first-degree density; secondary punctures well differentiated, more numerous than primaries on upper half, becoming sparse and finally disappearing medially; posterior border with a linear groove extending upward to spiracle. Scutellum minutely punctate to impunctate, apex much wider than diameter of lowest primary punctures. Metanotum with apical callosity, elsewhere densely coarsepunctate, with the primary punctures covering an area equal to

that of the interspaces and equalling the size of the largest primaries of the scutellum. Tegula plainly shagreened. Wings with first cubital mark clearly defined; radial cell equalling the second cubital cell. Propodeum with its areola one and one-fourth times longer than broad, sides convergent, rounded at apex where carinae are thickened, median carina expanded, and tapering to lowest fourth of areola, enclosed area flat and polished; lower sides with the anterior part finely striate and the posterior part minutely setulose; posterior aspect without medial carina. First tergite with preapical band not impressed, consisting of distinctly separate punctures about three rows wide. First sternite with disk densely covered with minute punctures, constricted half with shallow primary punctures and a median keel; apical sulca not well developed; lateral grooves absent. Second tergite with a single row of large apical punctures; tergites 3 to 5 with punctures becoming large toward apices, and with numerous minute but deep secondary punctures with sharply defined outlines scattered widely on posterior halves, apical primary punctures separated from apices of segments by distances much less than their diameters, and marked by even rows of conspicuous, yellowish hairs. Sternites two to five with apical rows of yellow hairs similar to those of dorsum; fifth sternite with its lateral denticle a strong, conspicuously elevated tooth, mediad of which there is a large orifice; fourth sternite with a vestigial orifice in a similar position. Length 14 mm.

Distribution.—Keikido, Chosen.

Holotype.—Cat. No. 41781, U.S.N.M. Male, Suigen, Chosen, May 10, 1923 (Clausen).

11. TIPHIA SINGULARIS, new species

Male.—Vertex with punctures back of and between ocelli and near inner margins of eyes of second-degree density. Front shagreened, with median carina well developed; primary punctures large, on anterior half from eye to eye their diameter very much exceeding width of narrow interspaces; area of punctures of first-degree density extending upward on sides to level of lowest ocellus; secondary punctures sparse on lower third. Antennocular distance greater than the width of antennal fossa. Clypeal extension with its apex shallowly emarginate, having a narrow, impunctate margin of uniform width; disk conspicuously shagreened; clypeoantennal distance equal to apical width of extension. Pronotum shagreened; primary punctures large and shallow, in a vague series of second-degree density, somewhat denser laterally; several secondary punctures in medio-anterior region. Sides of pronotum with a well defined, narrow median groove; disk finely striate above, and with large, round punctures at the alar angle. Mesepisternum faintly shagreened;

primary punctures large, shallow, but clearly outlined, of first-degree density, with tendency to grouping in rows; secondary punctures well differentiated and somewhat more numerous than the primaries, except in upper anterior region. Scutellum with its minutely punctate apex wider at places than diameter of the lowest primary punctures. Metanotum densely bipunctate, the primary punctures of third-degree density and much smaller than the largest on the scutellum. Wings with the usual hyaline lines scarcely visible; radial cell greatly exceeding second cubital cell in apical extension. Propodeum with areola one and one-fourth times as long as wide, with concave, converging sides; longitudinal carinae crenulate; median carina complete; side with its lower portion finely striate and without hairs; posterior aspect with median carina on lowest fourth. First tergite with preapical band not abruptly impressed, and consisting at center of a single row of punctures, expanding at sides, where it is also farther removed from apex. First sternite polished on disk, with numerous clearly outlined round punctures, and with a medial keel on anterior half, lateral grooves absent. Tergites 3 to 5 with fine, deep, clearly outlined punctures which become sparse apically; impunctate margin subobsolete, at most twice as wide as diameter of largest adjacent primary punctures; marginal linear groove usually complete across dorsum; lateral denticle of fifth sternite present as a longitudinal ridge over a large orifice with an upright, angular tooth in the floor of the orifice. Length, 8 to 12 millimeters.

Distribution.—Fukien and Chekiang, China.

Type.—Cat. No. 41782, U.S.N.M. Type, male Kuliang, China, 1926 (Jen).

Paratypes.—All males. Retained in the collection of the Japanese Beetle Laboratory: One, Hangchow, China, July, 1925 (Jaynes); 1, Kuliang, China, 1926 (Jen). Deposited with the U. S. National Museum: Twenty-four, Kuliang, China, 1925 (Jen). Deposited in the collections of the British Museum, the Illinois Natural History Survey, and the Philadelphia Academy of Natural Sciences: One each of the same lot as the last.

The single specimen from Hangchow differs slightly from the type in being larger, in having the third antennal joint distinctly longer than its greatest width, and in having the marginal grooves complete across the dorsum in only the third tergite. The large orifice on the fifth sternite, with the projecting tooth on its floor, is distinctly different from any other species examined. It may possibly be the male of one of the species of which females only are discussed in this paper, possibly of *sternocarinata* collected at the same locality. The associations are vague, however, and can not be accepted until supported by further data.

12. TIPHIA NOTOPOLITA, new species

Female.—Vertex with primary punctures back of ocellar triangle of third-degree density, though noticeably denser than on the lateral vertex. Front shagreened on lower third, with a median groove; primary punctures in preocellar area of second-degree density just anterior to ocellar triangle, and of third-degree density on either side, with several interspaces as wide as an ocellus. Clypeus with its lateral margin slightly convex; impunctate apex of extension poorly defined anteriorly but distinguishable one-fourth the distance to base of antennae. Pronotum with its transverse carina complete; primary punctures uniform in size and evenly distributed over the anterior dorsum without a trace of a transverse discal band; medial longitudinal extension of punctate area equal to that of impunctate area. Side of pronotum with a definite groove across the center broken by unsculptured interspaces; anterior half usually with several widely scattered, deep, round punctures. Metanotum impunctate over much or all of its anterior surface, without a dense medial patch of minute punctures. Metasternum shaped like an arrowhead, with the outer wings well pointed and directed backward. Legs with the major calcarium of hind tibia tapering from its base; hind basitarsus on the outside with a group of 3 or 4 stout spines, one of which is apical. Tegula red, with a posterior marginal groove, and with only a vague impression on the lateral margin, which does not terminate posteriorly in an abrupt, inwardly directed hook. Wings moderately smoky; second intercubital vein straight and joining the radius at an abrupt angle. Propodeal areola two and one-fourth times as long as wide; sides slightly convergent, all the carinae bordered with deep, crenulate grooves; median carina complete. Lower portion of sides of propodeum polished, striate, with a limited area of very minute hairs. Posterior aspect of propodeum quite completely bipunctate; its median carina present as a faintly elevated, flat-topped ridge on the lower three-fourths or more. First tergite with its preapical band well defined, not in an impression, and consisting of well-separated punctures irregular in size and spacing, narrowing to a single row at the middle. First sternite coarsely coriaceous anteriorly, with lateral grooves on the posterior half. Intermediate tergites with the apical punctures more elongate than usual, and interspersed with minute, vestigial punctures which are present over the dorsum on tergites 3 to 5. Pygidium densely and evenly punctate on basal half, with an impunctate emargination; apex strikingly free from wrinkles and not shagreened. Length, 6 to 10 mm.

Male.—Vertex with punctures scarcely denser just back of ocelli than on either side, everywhere of third-degree density. Front with

primary punctures moderately large; lower portion with a medial extension of punctures of first-degree density; a broad preocellar region having numerous interspaces broader than an ocellus; secondary punctures more numerous than primaries on lower two-fifths, extending upward as far laterally as medially. Antennocular distance greater than width of antennal fossa. Clypeal extension with its apical width about equal to the clypeoantennal distance; apex shallowly emarginate and very narrowly impunctate, with a thick edge. Pronotum with primary punctures of moderate size, largely of third-degree density, a few secondary punctures in the median anterior region; sides with coarse, anastomosing striations on the anterior half, with a series of diagonal rugae tapering toward the alar angle. Mesepisternum with primary punctures large, round, deep, clearly outlined, and separated by distances greater than their diameters, the interspaces with well differentiated secondaries which, at the center, are not much more numerous than the primary punctures. Scutellum with impunctate apex medially wider than diameter of lowest primary punctures. Metanotum with punctures much smaller than the largest primary punctures of the scutellum, and of sparse third-degree density; sometimes nearly impunctate or with median patch of dense secondary punctures. Tegula with a well-defined impressed line, continuous about the lateral and posterior margins, sometimes interrupted at outer hind corner. Wings with the radial cell not extending apically quite as far as second cubital cell. Propodeum with the areola rather variable, about one and one-half times as long as wide, lateral carinae on outside bordered with vague grooves, median carina extending nearly to transverse carina, enclosed area with definite transverse ridges; side with its lower region finely striate, without hairs; posterior aspect not finely punctate but reticulo-rugose, particularly about the median carina which is evident on the lowest three-fourths. First tergite with preapical band not in a definite depression, composed of a single row of punctures which is often curved toward the apex medially. First sternite irregularly punctate on disk, with an apical crenulate fossa; lateral grooves on posterior half, frequently extending inward anteriorly from the border of sternite. Tergites 3 to 5 not shagreened; with posterior punctures separated from margins at most by four times the diameter of the largest adjacent primary punctures; marginal linear groove complete, or outlined by interrupted gouges over dorsum of last four segments; lateral denticle of fifth sternite present as a longitudinal ridge arched over an orifice. Length, 6 to 8 mm.

Distribution.—Chekiang, Kiangsu, and Fukien, China; Keikido, Chosen; Kanagawa, Japan.

Type and allotype.—Cat. No. 41783, U.S.M.N. Type, female, Ningpo, China, August 14, 1925 (Chao). Allotype, Ningpo, China, September 1, 1925 (Chu).

Paratypes.—In the collection of the U. S. National Museum: One female, Yokohama, Japan, September 15, 1921 (Clausen); 1 male and 1 female, Ningpo, China, September 6 to 10, 1925; 2 males, Kuliang, China, 1926 (Jen); 3 females, Penniu, China, Nos. 134, 316, and 428, respectively; 2 females, Penniu, China, 1926 (Wong), Jaynes No. 116; 2 males, Suigen, Chosen, Jap. Beetle Par. Exp. No. 318, and 2 males, August 8 and 21, 1922 (King). Retained in the collection of the Japanese Beetle Laboratory: One male, Ningpo, China, September 1, 1925 (Chu), 1 female, Ningpo, China, September 2, 1925, D9. Deposited in the collection of the Illinois Natural History Survey: One male, Penniu, China, Jap. Beetle Par. Exp. No. 205; 1 female, Ningpo, China, September 8, 1925, D18. In the British Museum: One male, Kuliang, China, 1926 (Jen); 1 female, Ningpo, China, August 25, 1925, D3. To the Philadelphia Academy of Natural Sciences: One male from Kuliang, China, 1926 (Jen); 1 female, Ningpo, China, September 10, 1925. Notes by the junior author on his No. 116 refer to this species and variety.

All the males listed above are probably referable to the variety *notopolita*, but in this sex the varieties could not be distinguished. The two from Suigen may be *intermedia.* The male genitalia are very similar to those of *rufomandibulata.* No other taxonomic characters were found by which the varieties, in the male sex, could be separated or distinguished from males of *rufomandibulata.*

TIPHIA NOTOPOLITA var. INTERMEDIA, new variety

Female.—The variety, in this sex, has many of the characters both of *rufomandibulata* and of *notopolita notopolita*, but resembles the latter more strongly, and is probably more accurately placed here as a variety than as a separate species or as a variety of *rufomandibulata.* It differs from the variety *notopolita* in the following characters: Sides of the pronotum with a central groove broken by unsculptured interspaces as in *notopolita* or continuous. Metanotum sparsely punctuate with small primary punctures and usually with a dense medial patch of minute punctures. Tegula with a posterior marginal groove and usually with a lateral marginal groove, both terminating in pronounced inward-directed hooks at the outer hind angle.

Type.—Cat. No. 41784, U.S.N.M. Female, Suigen, Chosen, September 25, 1924 (Sato), Clausen No. 1855.

To this variety are referred the following female paratypes. In the collection of the United States National Museum: Six, Suigen, Chosen, August 8, 21, 23, and 24, 1922 (King), Rohwer No. 7;

1, Suigen, Chosen, August, 1923 (Clausen); 7, Suigen, Chosen, August 23, 1923 (Sato), Gardner No. 4, Rohwer No. 7; 1, Suigen, Chosen, September 11, 1924 (Sato); 2, Suigen, Chosen, September 12, 1925 (Sato), Gardner No. 4; 1, Suigen, Chosen, September 20, 1925 (Gardner), Gardner No. 13 equals Clausen No. 1862; 1, August, 1926 (Gardner), Gardner No. 4 equals Clausen No. 1855; 4, Suigen, Chosen, Jap. Beetle Par. Exp. No. 300; 1, Penniu, China, Jap. Beetle Par. Exp. No. 308–C2, October 7, 1927; 1, Kuliang, China, July 19, 1924 (Jaynes); 1, Kuliang, China, August 16, 1926 (Jen); 1, Kuliang, China, 1926 (Jen); 1, Hangchow, China, June 8, 1926 (Chao); 1, Penniu, China, September 8, 1925, No. 108. Retained in the collection of the Japanese Beetle Laboratory and deposited in the collections of the Illinois Natural History Survey and the British Museum: One each from Suigen, Chosen, August, 1926 (Gardner), Gardner No. 4 equals Clausen No. 1855 (used in breeding work). In the Philadelphia Academy of Natural Sciences: One, Suigen, Chosen, September 29, 1925 (Sato) Gardner No. 4.

A number of specimens have vestigial lateral carinae on the constricted part of the first sternite, but these are not as high as in *sternocarinata*, and the interval between them and the medial carina is definitely coriaceous, and is not as deeply grooved. To this species and variety have been referred Clausen's material under his number 1855, which equals Gardner's number 4, and also a part of the material under Gardner's number 13, which included specimens of *popilliavora* as well.

The *notopolita* group, including the two varieties and the closely related *rufomandibulata* and *sternocarinata*, have furnished one of the most puzzling problems connected with any of the *Tiphia* considered in this paper. Individual females of the two varieties, which might easily be considered of two different species, can be picked out, but intergradients are numerous, and varietal rank seems the highest to which they should be assigned. Male genitalia of the two varieties and of *rufomandibulata* have been studied, and show no differences of importance.

13. TIPHIA RUFOMANDIBULATA Smith

Plate 3, fig. 20

Tiphia rcfomandibulata Smith, Trans. Ent. Soc., London 1873, p. 184.—Perez, Bull. Mus. Paris, 1905, p. 87.

The following notes were made from a study of specimens compared by Mr. Gahan with the type female from "Hiogo," Japan. Mr. Gahan, however, did not have specimens of either of the closely related varieties of *notopolita* with him at the time of comparison.

Since these varieties occur in Chosen, which is much nearer the habitat of the type of *rufomandibulata* than is the locality of the Chinese specimens seen by Mr. Gahan, it is possible that the species we have named *notopolita* may be taxonomically nearer the type than the one selected.

Female.—Vertex with primary punctures of first-degree density in very limited patches between ocelli and near upper part of eyes, elsewhere largely of second-degree density with irregular impunctate spaces. Front shagreened on lower half, with a well-developed median groove which extends half way to ocellus, and with an impunctate stripe; primary punctures more densely grouped on anterior half, where they are evenly distributed between the eyes, mostly of second-degree density, with vaguely defined, trident-shaped impunctate area below ocelli. Clypeus with its lateral margin distinctly convex; apex impunctate except for numerous, barely visible punctures, the impunctate apex poorly defined above by coarse punctures which are irregular in size and arrangement. Pronotum with its transverse carina complete; primary punctures of uniform size and evenly distributed over the anterior portion of the dorsal aspect; no transverse discal band; medial longitudinal extension of punctate area slightly greater than that of impunctate area. Side of pronotum with definite groove across center, along the bottom of which are numerous small rugulae, especially from center to alar angle; no group of well-developed primary punctures on anterior half. Metanotum finely, uniformly, and sparsely punctate, punctures much smaller than those of the scutellum; dense, minute punctures lacking. Legs with major calcarium of hind tibia tapering uniformly; hind basitarsus on outside with a group of four straight, stout, lanceolate spines, one of which is apical. Tegula black, polished, with very shallow marginal impression laterally and another impression on posterior margin, both terminating in inward-directed hooks at the lateral, posterior corner; outer impression sometimes lacking. Wings densely smoky; second intercubitus sinuous, joining radius in a rounded angle, usually without spur; first cubital mark barely perceptible. Propodeal areola with its sides converging, scarcely two times as long as wide; medial carina complete and of the same size throughout, somewhat flattened and polished on top and bordered by numerous short transverse ridges. Lower portion of sides of propodeum rugulose over all the surface, but more conspicuously so toward upper rugose portion. Posterior aspect of propodeum conspicuously bipunctate, particularly on the lateral extension; median carina present as a strong, rounded, tapering rib on the lower three-fourths, bordered by irregular transverse rugosities. First tergite with a rather large median patch of dense, minute punctures;

preapical band well defined, not in depression, but consisting of irregularly distributed, well separated punctures narrowed to a single row at the center. First sternite with lateral grooves on posterior half; no other sculpturing. Tergites 4 and 5 with a more or less interrupted row of minute non-setigerous punctures just before the apex; apical setigerous punctures scarcely farther removed from the apex medially than at the sides. Pygidium densely and evenly punctate on basal three-fifths, with an elongate, impunctate, shagreened emargination; apex faintly wrinkled and shagreened. Genitalia with outer clasper abruptly constricted near middle, outer edge deeply emarginate; second genital segment with a small, slender apical hook, inner margin narrowly convex near the hook; distal portion of aedeagus with lateral processes lacking, apical lobes broadly inflated and somewhat polygonal in outline; proximal portion of aedeagus slender; constriction separating the two portions not well marked. Length, 10 to 11 mm.

Male.—We have been unable to separate the male from the male of *notopolita.*

Distribution.—Hyogo, Japan; Chekiang, China.

These notes were based on the following material. In the collection of the Japanese Beetle Laboratory: One female, Hangchow, China, October 3, 1924 (Chao); 3 males and 18 females, Hangchow, China, July, 1925 (Jaynes); 6 males and 5 females with dates from July 10 to July 24, 1926 (Chao); 2 questionable males, 1 from Foochow, China, July 19, 1924 (Jaynes), and 1 from Ningpo, China, emerged from cocoon August 27, 1925. In the collection of the U. S. National Museum: One female, Hangchow, China, July 7, 1925 (Chao); 3 females, Hangchow, China, July, 1925 (Jaynes). Deposited in the collections of the Illinois Natural History Survey, the British Museum, and the Philadelphia Academy of Natural Sciences: One female to each from Hangchow, China, July, 1925 (Jaynes).

One female collected at Hangchow, China, October 3, 1924, resembles *notopolita* in having the second intercubitus straight and the metathorax impunctate anteriorly, but is typical in other characters.

14. TIPHIA STERNOCARINATA, new species

Female.—Closely related to *notopolita notopolita*, from which it differs in the following particulars. Dorsum of pronotum shagreened on the anterior third. Side of pronotum with the central groove deep and uniformly tapering to alar angle without interrupting rugulae; no group of punctures on the anterior half. Mesepisternum conspicuously shagreened. Metanotum finely bipunctate apically, with tendency to be impunctate anteriorly. Metasternum with its outer posterior angle rather more sharply produced, and inclined posteriorly.

Tegula largely reddish, without true marginal grooves, at most with an upfolded posterior margin. First sternite not coriaceous anteriorly, with its basal medial process elevated into a sharp ridge on either side of the short medial keel. Length 9 to 12 mm.

Male.—Not known.

Distribution.—Fukien, China.

Type.—Cat. No. 41785, U.S.N.M. Female, Kuliang, China, August 16 to October 10, 1926 (Jen).

Paratypes.—In the United States National Museum: Three females from Kuliang, China, August 16 to October 10, 1926 (Jen). Deposited in the collections of the British Museum, the Japanese Beetle Laboratory, the Illinois Natural History Survey, and the Philadelphia Academy of Natural Sciences: One female to each from Kuliang, China, August 16 to October 10, 1926 (Jen).

The variety *notopolita intermedia* often has carinae on each side of the antero-median keel of the first sternite, but it is also coriaceous in this region while in *sternocarinata* the corresponding area is smooth.

15. TIPHIA BREVICARINATA, new species

Female.—Vertex with patch of punctures of first-degree density back of ocellar triangle, scarcely any between ocelli, and nearly impunctate spots beside and diagonally behind posterior ocelli, elsewhere of second-degree or third-degree density. Front with primary punctures most densely grouped on anterior half, where they are not more dense medially than elsewhere, and are of first-degree density, thinning out above to second-degree and third-degree density without definite impunctate spots. Clypeus with its lateral margin strongly convex; extension impunctate except for numerous barely visible minute punctures, the impunctate area poorly defined above by coarse punctures which are irregular in size and arrangement, its longitudinal extension about one-third as great as the clypeoantennal distance. Antenna with its third joint slightly longer than greatest width; flagellum slightly fulvous beneath. Pronotum faintly striate anteriorly, with its transverse carina complete, but weakly developed; primary punctures of uniform size, and evenly distributed over the anterior dorsum; no transverse discal band; medial longitudinal extension of punctate area slightly exceeding that of impunctate area; side of pronotum with a definite groove across the center. Metanotum with punctures much smaller than those of scutellum; lateral angle with dense patches of minute secondaries. Legs with major calcarium of hind tibia widest near middle; hind basitarsus on outside with irregular group of several specialized lanceolate spines, one at apex. Tegula with inner hind angle considerably produced. Wings smoky. Propodeal areola convergent, with its

sides concave and its apex truncate; the carinae strong, and bordered by crenulate grooves; median carina somewhat expanded anteriorly, complete to apex of inclosure. A pair of unusual, short, transverse ridges on dorso-propodeum just before the transverse carina. Lower portion of sides of the propodeum shagreened to striate. Posterior aspect of propodeum lacking usual coriaceous sculpturing of the sides, but with scattered, shallow punctures medially, median carina present on lowest three-fourths, with short lateral ridges. First tergite with apical band fairly well defined, expanded laterally, not depressed, the punctures everywhere distinctly separated. First sternite with lateral grooves complete to anterior apex and bordered by shallow reticulate punctures. Tergites 3 to 5 with impunctate apices scarcely one-tenth the total width of punctate portion. Pygidium finely and uniformly punctate on basal three-fifths; impunctate apex wrinkled and faintly shagreened toward punctures. Length, 13.5 mm.

Distribution.—Kiangsu, China.

Holotype.—Cat. No. 41786, U.S.N.M. Female, Penniu, China (Wong) No. 269.

16. TIPHIA LYRATA Magretti

Plate 2, fig. 12

Tiphia lyrata Magretti, Ann. Mus. Civ. Genova, vol. 32, p. 252, 1892.

Female.—Vertex with a few punctures of second-degree density just behind the ocellar triangle and narrowly along upper eye orbits, punctures of sparse third degree elsewhere. Front with vestigial impunctate stripe; primary punctures not more dense above base of antennae than on either side, largely of first-degree density on lowest third, particularly along the eyes, of second-degree to third-degree density around ocellar triangle below, without symmetrical impunctate areas. Antenna sometimes fulvous beneath. Clypeal extension with longitudinal extension of its impunctate margin about one-third as great as clypeoantennal distance. Pronotum with transverse carina usually complete; primary punctures unusually uniform in size and distribution, without trace of a transverse discal band, and only slightly denser medially than on either side, density from first to third degrees; secondary punctures sparse on anterior half of punctate area; impunctate apex with a narrow antero-medial prolongation which makes the punctate portion narrower medially than the impunctate. Side of pronotum with a shallow groove extending about half way across the center, otherwise much smoother than usual below the groove. Metanotum nearly impunctate, its few punctures much smaller than the primary punctures of the scutellum. Legs with major calcarium of hind tibia not abruptly bent or wider near middle than at base; hind basitarsus on outside with three

rather inconspicuous spines in a row, one of which is apical. Tegula reddish, semi-transparent. Wings slightly smoky. Propodeal areola vase-shaped in outline, nearly twice as long as wide; carinae bordered by interrupted grooves; median carina extending to lowest fifth or more; on each side of median carina, a much shorter, sinuous carina; enclosed area shagreened anteriorly, reticulated behind. Lower portion of side of propodeum weakly rugulose, without apparent hairs. Posterior aspect of propodeum without medial carina. First tergite with a preapical band of punctures rather irregular as to size and arrangement, but well separated, except laterally, where the band is slightly expanded and the punctures coalesced. First sternite polished, with very little hair, and with lateral grooves on posterior half or less. Tergites 2 to 4 with impunctate apices widest at middle, where they are at least four times as wide as the adjacent primary punctures; tergite 4 with a vestigial row of minute punctures extending dorsally over the center of the otherwise impunctate apex. Pygidium densely reticulo-punctate on basal half; apical section plainly wrinkled longitudinally; sting stylet and palps extruding from tip of abdomen for distance equal to half width of pygidium Length, 8 to 9 mm.

Distribution.—Burma; Fukien and Kiangsu, China.

These descriptive notes are based upon 5 females. Retained in the collection of the Japanese Beetle Laboratory: One, Kuliang, China, August 16, 1926; 1, Yangchow, China, August 18, 1924 (Wong). In the United States National Museum: One, Kuliang, China, August 16, 1926. Deposited in the collections of the British Museum and the Illinois Natural History Survey: One to each from the same lot as the last.

One female from Yangchow, August 18, 1924 (Wong), differs slightly from the Kuliang specimens in having the groove across the middle of the pronotum reduced to a vague line of short, shallow gouges on a smooth field.

This is an unusual species in that it has five longitudinal areolar carinae. All the specimens mentioned above agree with the original description and with determined specimens examined in the British Museum by Mr. Gahan. A specimen compared with the type at the Museo Civico di Storia Naturale, Genoa, Italy, by Prof. L. Masi was found to agree in all particulars except that the abdominal punctures were more evident, especially on the last tergite.

17. TIPHIA CAPILLATA, new species

Female.—Vertex with primary punctures not denser medially than elsewhere, of second-degree and third-degree density excepting a narrow line of first-degree density near upper eye-margin. Front

plainly shagreened; a medial groove usually well developed; primary punctures rather regularly distributed, increasing in density toward region just above antennae where they are of first-degree density; hairs directed conspicuously outward. Clypeus with the lateral margin decidedly convex; impunctate apex frequently red, limited by irregularly grouped punctures which approach the apex medially, causing the impunctate area to be much broader at the sides than at the center. Mandibles usually without median groove. Antenna with the first joint angulate apico-ventrally; third joint slightly longer than the greatest width; flagellum slightly fulvous beneath. Pronotum with its transverse carina usually complete but weakly developed; primary punctures densely distributed, with a tendency to concentrate medially and in a discal band; secondary punctures widely distributed and occurring densely just back of the carina on the sides of dorsum; punctate area conspicuously shagreened, its median longitudinal extension slightly narrower than that of the impunctate portion. Side of pronotum unusually free from sculpturing, with the usual rugulae at the ventral corner sometimes enlarged to shallow grooves at their upper extension; several distinct punctures along the posterior dorsal border; the upper disk highly polished. Scutum with its notauli and its antero-medial groove usually continuous; conspicuously shagreened. Metanotum densely bipunctate with a polished callosity. Legs with tibiae and tarsi of first two pair bright red; major calcarium of hind tibia uniformly tapering; hind basitarsus with two pricklelike spines on outside near middle, none of the same kind at the apex. Tegulae thin, semitransparent, reddish, polished. Wings nearly hyaline; hyaline lines not present. Propodeal areola almost rectangular in outline, twice as long as wide, carinae uniform and narrow, without conspicuous bordering grooves; median carina not quite complete. Lower portion of sides of propodeum wavy-rugose, not well differentiated from the rugose upper half where the ridges are weak and disappear posteriorly. Posterior aspect of propodeum with clearly defined punctures, median carina not raised but defined by parallel grooves extending beyond lower half. First tergite usually with a small patch of minute punctures on the anterior slope; preapical band vaguely defined by very fine, widely separated punctures in a broad, shallow depression. First sternite polished and without sculpturing, lateral grooves lacking. Intermediate abdominal tergites with large apical setigerous punctures extending medially into subdiscal region. Pygidium sparsely punctate on upper three-fifths, area of interspaces greatly exceeding that of punctures, no marked impunctate emargination; apex faintly wrinkled below lowest punctures; all conspicuously shagreened. Length, 8.5–9 mm.

Male.—Vertex with primary punctures everywhere of third-degree density, scarcely more abundant back of ocelli than on either side of them. Front shagreened; primary punctures very small; punctures of the lower front scarcely of first-degree density; preocellar area vague, with primary punctures uniformly of third-degree density; secondary punctures not apparent; lower part of front masked by dense, appressed white hair directed laterally; a conspicuous medial impression on lower half. Antennocular distance greater than width of antennal fossa. Clypeal extension with apex shallowly emarginate, and with an impunctate border masked by dense appressed hairs; clypeoantennal distance one and one-fourth times width of extension. Antenna with all segments of flagellum broadly suffused with red below. Pronotum more or less masked by appressed white hair directed laterally on the disk; with primary punctures small and poorly differentiated from the secondary punctures which are numerous, particularly in latero-discal patches. Side of pronotum mostly polished and striate. Mesepisternum with primary punctures small, very shallow, and poorly outlined, largely of third-degree density; secondary punctures poorly differentiated, slightly more numerous than the primary punctures on upper half; with linear groove extending along the posterior border to subalar callosity. Scutellum with impunctate apical area not as wide as the largest primary punctures. Metanotum conical, with impunctate apical callosity, surrounding which are primary punctures of first-degree density nearly the same size as the largest primary punctures of the scutellum. Tibiae and tarsi reddish. Tegulae reddish yellow, very thin, and nearly transparent. Wings hyaline; radial cell much exceeding second cubital cell in apical extension. Propodeum with areola rectangular in outline. slightly longer than wide; longitudinal carinae flattened, without grooves on outside; enclosed area polished; laterodorsum finely punctate; lower portion of sides finely striate, not clearly defined from the upper rugose region; posterior aspect with fine setulose punctures. First tergite with preapical band of shallow, vaguely outlined punctures widely scattered in a shallow depression. First sternite conspicuously convex anteriorly, without trace of median keel, with disk polished and sparsely fine-punctate; apical groove obsolete, and lateral grooves not present. Intermediate tergites with the primary punctures small, shallow, and sparse; with impunctate apices as wide as five times the diameter of nearest adjacent primary punctures. Length, 6 to 7 mm.

Distribution.—Assam, India.

Type and allotype.—Cat. No. 41787, U.S.N.M. Type, female, Shillong, India, Jap. Beetle Par. Exp. No. 202. Allotype, male, Shillong, India, Jap. Beetle Par. Exp. No. 202.

Paratypes.—In the National Museum: Two females and 10 males, Jap. Beetle Par. Exp. No. 202; 1 male, unlabelled. Retained in the collection of the Japanese Beetle Laboratory: One female and 1 male, Jap. Beetle Par. Exp. No. 202. In the collections of the British Museum, the Illinois Natural History Survey, and the Philadelphia Academy of Natural Sciences: One each of the same lot as those retained at the Japanese Beetle Laboratory.

From cocoons collected in India, which were mostly of *pullivora*, *capillata*, and *levipunctata*, adults were reared in limited numbers at the Japanese Beetle Laboratory.

Mr. Gahan reports that *fuscinervis* Cameron is represented in the British Museum by a female and 2 males from the Kanga Valley. The original description is from a female collected at "Mussori" by Rothney. *Tiphia capillata*, according to Gahan, is the same species as the specimens in the British Museum determined as *fuscinervis*, but since the type of *fuscinervis* was not examined, the authors consider it best to call the specimens listed above a new species.

18. TIPHIA LEVIPUNCTATA, new species

Female.—Vertex with primary punctures scarcely denser medially than on either side, of third-degree density except narrow line of first degree near eye. Front faintly shagreened, with a linear medial impression on lower half; primary punctures very small and everywhere of third-degree density, though much more sparse on upper half, where there are a number of interspaces two to three times as broad as an ocellus. Clypeal extension with the length of its impunctate margin uniform from side ot side, and more than half as great as clypeoantennal distance. Mandibles, apex of first antennal joint, and under side of flagellum fulvous. Pronotum with its transverse carina complete, though weak; primary punctures sparse and poorly outlined, nearly as dense on lateral disks as medially, transverse discal band weakly developed; secondary punctures not apparent; punctate portion with its longitudinal extension medially as great as the impunctate apex. Side of pronotum with a vague central groove in the midst of finer striations. Metanotum with impunctate spots on disk and dense minute punctures about the margins, none of which are nearly as large as the primaries of the scutellum. Legs with the trochanters, femora, and tibiae of the last two pairs, as well as the inner surfaces and tarsi of the first and the tarsi of the second bright red; major calcarium of the hind tibia widest just before the middle; hind basitarsus with three lanceolate spines on the outside, one of which is apical. Tegula red, thin, semitransparent. Wing hyaline; terminal stump of cubital longer than preceding abscissa, sinuous on a course perpendicular to costa; stigma much less than

twice as long as wide, with radius joining it near its apex. Propodeal areola slightly convergent, with concave sides, two and one-half times as long as wide, carinae of uniform height throughout, bordered by irregular grooves, median carina on upper five-sixths. Upper portion of sides of propodeum feebly rugose and not clearly differentiated from the lower portion, which is faintly striate, with microscopic hairs. Posterior aspect of propodeum feebly sculptured, with faint carina on lower half or less. First tergite with its preapical band in a faint depression and consisting of a single row of small punctures separated by interspaces exceeding their diameters. First sternite as broad as long, coriaceous at constriction but becoming minutely setulose posteriorly along the sides; lateral grooves on posterior half or less. Tergites with punctures rather small; length of impunctate apices of intermediate tergites more than half length of punctate portion medially. Pygidium rather finely punctate on upper half; apex scarcely wrinkled. Length, 6 mm.

Male.—Not known.

Distribution.—Assam, India.

Type.—Cat. No. 41788, U.S.N.M. Female, Shillong, India, Insectary reared, 302–0.

Paratype.—One female in the collection of the Japanese Beetle Laboratory, from the same lot as the type.

This species was obtained from cocoons collected in India and shipped to the New Jersey station. Emergence occurred in the fall of 1927.

19. TIPHIA POPILLIAVORA Rohwer

Plate 1, fig. 3; plate 3, figs. 21, 22; plate 4, figs. 27, 28

Tiphia popilliavora Rohwer, Proc. Ent. Soc. Wash., vol. 26, p. 89, 1924.—Clausen, King, and Teranishi, U. S. Dept. Agr. Bull. 1429, pp. 33–39, fig. 24, 1927.—King and Hallock, Journ. Econ. Ent., vol. 18, p. 356, 1925.—King, Allen, and Hallock, Journ. Econ. Ent., vol. 20, p. 368 and p. 373, 1927.

The following notes are supplementary to the original description.

Female.—Vertex with several irregular patches of primary punctures of first-degree density, the one immediately back of the ocellar triangle much denser than the area on either side of it; minute punctures in irregular linear series on the median dorsal line extending from the occipital region towards the ocellar triangle. Mandibles with an uninterrupted median groove. Pronotum not shagreened, with a fairly well differentiated transverse discal band; punctures on lateral disks sparse, with distinct primaries always present. Scutum with its notauli and its antero-medial groove not continuous. Metanotum sparsely bipunctate, with median longitudinal impression; largest punctures scarcely half the size of those of the scutellum. Leg

of the usual type of those with grooved hind basitarsus, the basitarsus having also a group of stout spines on the outside and one of the same type at the apex; major calcarium of the hind tibia widest at the bend near the middle. Tergites without preapical groove or interrupted minute punctures, the impunctate margin about four times width of largest adjacent primary punctures at middle of dorsum.

Male.—Vertex with numerous minute punctures on the interspaces back of the ocellar triangle, densest along the median line; front with conspicuous dense secondary punctures extending upward on the interspaces to the level of lowest ocellus. Antennocular distance about equalling the diameter of an antennal fossa. Clypeoantennal distance one and one-fourth times width of clypeal extension at its apex, margin of latter broadly impunctate and upcurled. Flagellum of antenna black; third antennal joint not longer than board. Mesepisternum with its secondary punctures well differentiated from the primaries and more numerous everywhere, the interspaces densely studded with them. Scutum with impunctate apex wider than the diameter of the largest of the lower primary punctures. Metanotum usually with a vague medial impression; densely beset with primary punctures nearly as large as the largest of the scutellum. Preapical band of first tergite nearly uniform in width, its anterior margin often abruptly impressed at the sides, and its punctures of uniform size, moderately well separated, in a series about three punctures wide. First sternite with polished disk, lateral grooves on posterior half, coriaceous to shallowly punctate anteriorly, with short anteriomedial keel. Tergites shagreened, without grooves or vestigial punctures over the apical dorsal margins, the impunctate apices medially only about three times as long as width of largest adjacent primaries. Sixth sternite with an appressed denticle, its elevated edge rather long, and more nearly parallel to the apex of the sternite than to the longitudinal plane. The impunctate, polished medial stripe of the hypopigium narrow and linear.

Distribution.—Iwate, Kanagawa, Japan; Keikido, Chosen; Kiangsu and Chekiang, China; New Jersey, United States of America.

In addition to the type material at the U. S. National Museum, the writers have examined the following material in the collections of the U. S. National Museum and the Japanese Beetle Laboratory: Recoveries made at Riverton, N. J., 11 males, August 12, 1926 (Allen); 18 males with dates from August 9 to 16, 1927; 38 females, 1927. From Morioka, Japan, 1 female, August 20, 1920 (Clausen). From Kowai, Japan, 1 female, September 1, 1921 (Clausen); 48 males and 4 females, reared at Riverton in 1922, Exp. 4; 16 males and 3 females, reared at Riverton in 1923, Exp. 76; 6 males and 75 females, August, 1926; 2 females, no date. From Yokohama, Japan 1 male

and 1 female, September 15, 1921 (Clausen); 1 female, October 20, 1921 (King). From Suigen, Chosen, 1 female, August 24, 1922 (King); 43 females, August, 1923 (Clausen); 3 females, September, 1924 (Gardner), Clausen No. 1856; 3 females, September 11, 1924 (Sato), Clausen No. 1856, parasite on *Popilla atrocoerulea;* 3 females, September 15, 1924 (Sato) Clausen No. 1862, parasite on *P. castanoptera;* 3 females, September, 1925 (Gardner), Clausen No. 1856; (Sato), Clausen No. 1856, parasite on *Popillia atrocoerulea;* 3 females, September, 1925, Gardner No. 13 equals Clausen No. 1862; 1 male and 3 females, insectary reared, Riverton Exp. 220; 4 males, insectary reared, Riverton Exp. 320; 1 male and 1 female, insectary reared, Riverton Exp. 321; 1 female, insectary reared, Riverton Exp. 318; 2 females, September 12, 1925 (Sato), Gardner No. 5; 2 females, September 26 and 30 (Sato), Gardner No. 13; 2 males, Gardnerf No. 5 From Penniu, China, 127, dates from September 24 to October 9, 1925, " laid on P. T. grubs " (*Popillia formosana* Arr.); 1 female, September 30, 1925 (Wong), " laid on P. T. grubs "; 29 females, between October 8 and 16, 1925 (Wong); 124 females, 1926, Jaynes No. 115 (Wong); 9 males and 20 females, insectary reared, Riverton Exp. 205; 2 males and 3 females, insectary reared, Riverton Exp. 305; 44 females, numbered specimens. From Hangchow, China, 13 females, between September 4 and October 30, 1924, lettered, respectively, P5, T5, V8, Z6, D6, W7, X7, S8, L8, U7, N8, K8, and V7; 1 female, September 19, 1924. Specimens from the above list have been deposited in the collections of the British Museum, the Illinois Natural History Survey, and the Philadelphia Academy of Natural Sciences.

This group seems to be one of the dominant complexes in the *Tiphia* of the Oriental region. After studying a much larger series than Rohwer had at the time his description was made, the writers accept his finding on the species, with minor exceptions. His seven paratype females from Suigen, Chosen, which were collected August 20, 1923, by C. P. Clausen and recorded, under Clausen No. 3, as parasitic on the grubs of *Phyllophaga* species, are unquestionably another species which we have described as *phyllophagae.* Two additional paratype females collected by J. L. King at Suigen, Chosen, August 26, 1922, also belong under *phyllophagae.* Certain biological differences exist between the material reared in Japan and that reared in China or Chosen, but a prolonged study of our material has failed to reveal any constant anatomical characters of sufficient importance to elevate them to the rank of separate species. In the Japanese females examined, the pronotal ridge is almost always complete across the dorsum, there is present in a small number a

very weakly developed carina on the posterior aspect of the propodeum, the sides of the pronotum have merely a diminishing series of parallel rugulae extending across the center to the alar angle, and the length varies from 8.5 to 10 mm. In the females from Chosen the pronotal carina is somewhat more strongly developed, the carina on the posterior aspect of the propodeum is developed on the lower fourth to half in nearly all specimens, there is often a tendency towards a definite groove on the center of the side of the pronotum not like the regular diminishing rugulae in the Japanese race, and the length is usually about 12 mm. The Chinese females are intermediate. Most of them have the pronotal carina more weakly developed across the dorsum, the carina on the dorsal aspect of the propodeum slightly developed, the side of the pronotum more nearly approaching that of the Japanese race, though not so deeply rugulose. Fewer differences have been noted in the males. The genitalia of the males of the Japanese, Chosen, and Chinese races of *popilliavora* resemble one another and the genitalia of the males of *phyllophagae*, and present to the writers no differences of diagnostic importance.

20. TIPHIA PHYLLOPHAGAE, new species

Plate 3, fig. 17

Female.—Vertex usually without minute punctures dorsally, rarely with a few along the medial line; with primary punctures denser just back of ocelli than on either side, mostly of second-degree density, with irregular impunctate areas laterad to outside ocelli. Front with primary punctures not denser on anterior half than elsewhere, everywhere of second-degree density, without pronounced impunctate areas. Clypeus with its lateral margin straight; impunctate margin of extension defined by an irregular row of punctures, its length two-fifths the distance from apex of clypeus to base of antennae. Mandibles with a rather shallow but continuous median groove. Pronotum with its transverse carina usually complete, though weakly developed; punctures of variable size, secondaries not well differentiated from primaries; primary punctures densely grouped in a very distinct though irregular transverse discal band and in a small medial patch, on either side of which they become very small and sparse; lateral extensions of discal band with 3 or 4 punctures much larger than the others; punctures on lateral disks and on angle of discal band just anterior to tegula largely true secondaries. Sides of pronotum with a very definite groove across the center merging with less conspicuous anastomosing grooves anteriorly; conspicuously striate on ventral corner, with a few punctures along the dorsal border. Metanotum usually with a shallow median impression;

posteriorly densely bipunctate, the larger punctures not nearly equaling the largest punctures of the scutellum in size. Legs with major calcarium of hind tibia having a distinct bend near the middle where calcarium is slightly wider than at base; hind basitarsus with a groove and with a group of 3 or 4 lanceolate spines on the outside, one of which is apical. Tegula with inner hind corner not produced in a broad angle, only sparsely hairy, with no hairs extending far above tegula when viewed from opposite side. Wings smoky; first cubital mark vaguely defined. Propodeal areola with sides nearly parallel, two to two and one-half times as long as wide; its carinae narrow, bordered by well developed grooves; median carina complete. Lower portion of side of propodeum mostly shagreened, with a patch of very fine hairs posteriorly. Propodeal slope without well developed punctures; median carina usually confined to lowest two-thirds. First abdominal tergite with its preapical band varying from one puncture wide at center to several at the sides, not in a depression, most of the punctures separated. First sternite with lateral groove complete to near anterior apex, with shallow punctures anteriorly. Tergites with punctures not farther from apex medially than laterally; impunctate border three to four times the width of hindmost primary punctures. Pygidium densely reticulo-punctate on basal three-fifths; impunctate apex with numerous wrinkles, broadly shagreened on wrinkled portion. Length, 9 to 14 mm.

Male.—Vertex with dense secondary punctures invading the dorsum from behind on a front wider than ocellar triangle; primary punctures back of ocellar triangle of first-degree density. Front faintly shagreened, with primary punctures on lower portion sparser and more limited in distribution medially than along eyes; preocellar area with numerous interspaces nearly as broad as ocellus; secondary punctures forming a dense patch on lower two-fifths, extending upward slightly more medially than near the eye. Antennocular distance equal or slightly greater than width of antennal fossa. Clypeal extension with its apical width from four-sevenths to two-thirds the clypeoantennal distance; apex shallowly emarginate; margin narrowly but distinctly polished, impunctate, and slightly upcurled. Pronotal punctures with clearly defined margins, somewhat denser medially than on humeri, mostly of third-degree density; secondary punctures widely and sparsely distributed. Side of pronotum finely striate, with a strong central groove which is usually uninterrupted. Mesepisternum with primary punctures small, deep, and clearly outlined, everywhere of third-degree density; secondary punctures much more numerous than primaries, densely studding the interspaces. Scutellum with impunctate apex not as

wide as diameter of the apical primary punctures. Metanotum densely punctate, with primary punctures nearly as large as those of the scutellum. Tegula with only a vague, shallow impression on the anterior lateral margin. Wings with radial cell equalling second cubital cell in apical extension. Propodeum with its areola from one and one-fourth to one and one-half times as long as wide, its sides usually slightly convergent and concave, the median carina wider than the lateral carinae, flattened on top, and usually ending abruptly just before apex of areola, enclosed area irregularly and transversely rugose and granulate; lower portion of sides densely shagreened; posterior aspect granulate, the minute punctures poorly outlined, the median carina developed on lower half or more. First tergite with preapical band wide, its anterior margin somewhat abruptly impressed, the punctures well differentiated only on the posterior border. First sternite with apical fossa obsolete; disk polished, impunctate; lateral grooves on posterior half, curved upward anteriorly; a sharp median keel on anterior half. Tergites 3 to 5 usually shagreened; punctures deep, with clearly outlined margins; impunctate margins absent, or at most only as wide as the diameters of the largest adjacent primary punctures; denticle on fifth sternite appressed, its elevated margin moderately long, crescent-shaped, and nearly parallel to apex of sternite, frequently with smaller denticles similarly located on the fourth and third sternites. Genitalia, in ventral aspect, with the outer clasper abruptly constricted near the middle, the apical portion very broad and vaguely quadrangular; second genital segment with its apical hook roundly and bluntly pointed; the inner hind margin with a pronounced rounded angle; distal portion of aedeagus with its apical lobes larger than the lateral processes; the proximal portion of the aedeagus broader apically them at its base.

Distribution.—Keikido, Chosen; Iwate, Japan; Kiangsu, Chekiang, and Fukien, China.

Type and allotype.—Cat. No. 41789, U.S.N.M. Type female and allotype, male, Suigen, Chosen, August, 1923 (Clausen).

Paratypes.—Retained in the collection of the Japanese Beetle Laboratory: Four females and 2 males, Suigen, Chosen, August, 1923 (Clausen). Deposited in the collections of the British Museum, the Illinois Natural History Survey, and the Philadelphia Academy of Natural Sciences: Four females and 2 males to each, of the same lot as the above. Deposited with the United States National Museum: From Suigen, Chosen, 4 males, August 17 and 21, 1922 (King); 1 female, August 23, 1923 (Sato); 1 female, August 23, 1923 (Sato), Gardner No. 4; 2 females, August 25, 1923 (Sato), Clausen No. 1854; 2 males and 40 females, August, 1923 (Clausen); 1 female,

August 15, 1925 (Sato), Gardner No. 3; 2 females, September, 1925 (Gardner), Gardner No. 3, Clausen No. 1854; 2 females, September 23, 1925 (Gardner), Gardner No. 3, Clausen No. 1854; 1 female, September 23, 1925 (Sato), Gardner No. 3; 1 male reared August 23, 1926 (Gardner), Exp. 210; 1 female, insectary reared, Riverton, Exp. 219; 1 male insectary reared, Riverton, Exp. 319; 8 males and 2 females. From Koiwai, Japan, 2 females imported. From Nanking, China, 1 male, June 12, 1924 (Jaynes); 1 male, July 24, 1924 (Illingworth); 2 females, August 6–7, 1924 (Wong), Nos. 43 and 45; 12 males, September 24–30, 1924 (Jaynes); 1 male, October 1, 1924 (Jaynes). From Chinkiang, China, 3 males, July 7, 1924; 1 male, July 20, 1924 (Illingworth); 6 males, July 2–26, 1924 (Jaynes); 30 females, July 26–August 26, 1924 (Jaynes); 8 males and 1 female, reared September 10–17, 1924, from eggs laid July 10–August 3, 1924 (Jaynes); 3 males, August 9, 1924 (Jaynes); 1 male, June 26, 1925 (Jaynes); 1 female, July 5, 1925 (Wong); 10 females, 1925, "parasite on E grubs"; 21 females, 1925, numbered specimens; 2 females, no date, lettered specimens; 1 male without label. From Yangchow, China, 2 males, August 7–15, 1924 (Wong); 2 females, August 15 and 24, 1924 (Wong); 1 female, August 24, 1924 (Jaynes), No. 82. From Penniu, China, 1 female and 2 males, June 25, 1925 (Wong); 2 females, July 1, 1925 (Wong); 1 female, July 21, 1925 (Wong); 160 numbered females, 1925 (Wong); 3 females, September 22 to October 7, 1925, with ovipositional data (Wong); 4 females with ovipositional data (Wong); 2 females numbered, but without date; 1 female, September 29 (no year), presumably from Penniu; 5 females, with ovipositional data, presumably from Penniu; 1 female, reared from No. 105, presumably from Penniu; 6 females, 1926 (Wong), Jaynes No. 113. From Zakow, China, 1 male, June 24, 1924 (Jaynes). From Hangchow, China, 38 females, numbered specimens, September 19–October 24, 1924 (Chao); 1 male, August 31, 1924 (Jaynes); 1 female, June 26, 1925 (Jaynes); 7 females, July, 1925 (Jaynes); 1 male, June 17, 1926 (Chao); 1 female, July 21, 1926 (Chao). From Kuliang, China, 1 female, July 9, 1925, C1; 1 male, August 19, 1925; 1 male, 1926 (Jen). From China, 62 females and 8 males, reared at Riverton, Exp. 31; 3 males, insectary reared, Exp. 207; 1 male, reared, No. 135; 1 male, August 8, 1927.

Seven females, Suigen, Chosen, August 20, 1923 (Clausen), and 2 females, Suigen, Chosen, August 26, 1922 (King), formerly paratypes of *popilliavora* have been placed under *phyllophagae*.

An unlabeled female and another from Suigen, Chosen, August, 1923, resemble *popilliavora* in having a line of several minute punctures on the vertex dorso-medially and in having no well defined groove on the center of the sides of the pronotum, but they have the

typical minute, sparse punctures on the dorso-pronotum and the vestigial medial mandibular groove of *phyllophagae*. A number of females which have been examined vary toward *ovinigris* in having the punctures of the transverse discal band of the dorsal portion of the pronotum more uniform in size and larger toward the lateral angle than in the typical *phyllophagae*. These seem on the whole, however, to be nearer the latter species than *ovinigris*, and have been referred to it. The specimens include 5 females from Penniu, China, 1925, 4 of which are labeled Nos. 130, 232, 263, and 293, respectively, 2 from Hangchow, China, X–3–1924 and VII–1925, 1 from Chinkiang, China, No. 20, 1925, and 1 from Suigen, Chosen, August 19, 1923. A male from Nanking, China, X–1–1924 (Jaynes), has a truncate, thickened apex to the clypeal extension, and the tegula is somewhat blacker than usual.

Material of this species from Chosen has been known for some time to the workers of the Japanese Beetle Project as Gardner No. 3, equalling Clausen No. 1854. Some of the Chinese material from Hangchow, Chinkiang, and Penniu was designated as Jaynes No. 113. One specimen from Chosen labeled Rohwer No. 7 belongs here. Association of the two sexes was made with the aid of collecting data and was confirmed by rearing male and female progeny of known females from China Exp. No. 31.

21. TIPHIA OVINIGRIS, new species

Female.—Differs from the description of the female of *phyllophagae* only in the following respects. The lateral expansions of the transverse discal band of punctures on the pronotum without three or four punctures which are very much larger than the other punctures in the discal band; punctures at the apex of the discal band, immediately anterior to tegula, approximately as large as those mediad of this point; lateral discal punctures of the dorsal aspect of pronotum somewhat larger than those of the same region in *phyllophagae*, being small primaries. Length, 11 to 13 mm.

Male.—Not known.

Distribution.—Keikido, Chosen.

Type.—Cat. No. 41790, U.S.N.M. Female, Suigen, Chosen, September 11, 1924 (Sato), Gardner No. 12 equals Clausen No. 1861.

Paratypes.—All females, from Suigen, Chosen. Retained in the collection of the Japanese Beetle Laboratory: One, September, 1926 (Gardner), Gardner No. 12 equals Clausen No. 1861. Deposited in the collections of the British Museum, the Illinois Natural History Survey, and the Philadelphia Academy of Natural Sciences: One from the same lot to each. Deposited with the United States National Museum: Two, August, 1923 (Clausen); 2, September 11, 1924 (Sato),

Gardner No. 12; 3, September 11, 1924 (Sato), Clausen No. 1861; 1, September 11, 1924 (Sato), Clausen No. 1856; 2, September 9 and 11, 1925 (Sato), Gardner No. 12; 4, September, 1925 (Gardner), Gardner No. 12; 8, September, 1926 (Gardner), Gardner No. 12.

This species is biologically distinct from *phyllophagae*. It has been known to Japanese beetle parasite workers in the Orient as Clausen No. 1861 and Gardner No. 12.

22. TIPHIA INCONSPICUA, new species

Plate 2, fig. 14

Female.—Vertex with primary punctures of second-degree density between and behind ocelli, elsewhere of third-degree density and with nearly impunctate spots on either side of medial patch. Front very faintly shagreened, with a short, narrow carina; primary punctures usually of third-degree density and evenly distributed over front, except in a narrow area along inner orbits, where they are of first-degree density. Impunctate apex of clypeal extension defined by a somewhat irregular row of coarse punctures, with its length equal to about half the distance from apex of clypeus to base of antennae. Mandibles with a median groove. Pronotum faintly shagreened, with its transverse carina usually complete but very weak; punctures much denser medially than on lateral disks, those just before impunctate apex much the largest although no discal band distinctly differentiated, punctures on lateral disks of third-degree density, definitely primaries though small; medial longitudinal extension of punctate area distinctly less than the impunctate. Sides of pronotum with a distinct groove across the center, and frequently with sparse punctures on upper half. Metanotum sparsely punctate, its largest punctures much smaller that the largest of the scutellum. Legs with major calcarium of hind tibia with a bend near middle, where it is slightly wider that at the base; hind basitarsus with a groove, and with four stout spines on the outside, one of which is apical. Propodeal areola subrectangular, from two to two and one-half times as long as wide; lateral carina bordered by grooves; median carina complete or nearly so; enclosed area smooth. Lower portion of sides of propodeum finely striate, and clothed with exceedingly fine, appressed hair. Posterior aspect of propodeum with scattered, round punctures antero-medially; median carina narrow, and complete or nearly so. First tergite with its preapical band consisting medially of a single, irregular row of punctures, expanding to several rows laterally, punctures distinctly separated only on posterior border. First sternite with its lateral groove developed on posterior half and again at constricted base, connected by a line of interrupted gouges; punctures or other sculpturing nearly lacking. Tergites

2 to 5 with impunctate margins at middle about three times the width of largest apical primary punctures. Pygidium densely and uniformly punctate on lower three-fifths, with a small, nearly impunctate emargination; apex wrinkled and strongly shagreened. Length, 9.5 to 11 mm.

Male.—Differs from the closely related *phyllophagae* in the following characters. The clypeoantennal distance is one and one-fourth times the apical width of the clypeal extension. The propodeal areola is without concave sides, being apparently longer, at least one and one-half times its width, and only very slightly convergent; the median carina is variable in length, but is usually half as long as the areola, scarcely thicker than the lateral carinae, and not broadly flattened on top. Denticle of fifth sternite is vestigial and much less conspicuous; no denticles on the two preceding sternites.

Distribution.—Chekiang and Fukien, China; Iwate and Kanagawa, Japan.

Type and allotype.—Cat. No. 41791, U.S.N.M. Type, female, Hangchow, China, September 18, 1924, K4; allotype, male, Kuliang, China (Jen).

Paratypes.—In the collection of the U. S. National Museum: Three females from Hangchow, China, labeled, respectively, September 19, 1924, O4, September 20, 1924, W4, and September 9, 1925, Y6 (Chao); from Ningpo, China, 4 females labeled, respectively, July 1, 1925 (Jaynes), August 28, 1925, D8, September 3, 1925, D10, and September 8, 1925, D17; from Kuliang, China, 9 females, August 16, 1926 (Jen), 1 male, August 29, 1926 (Jen), 6 females, 1926 (Jen), 2 males, September 1, 1926 (Jen); from Koiwai, Japan, 4 females, September 1, 1921 (Clausen); from Yokohama, Japan, 1 female, September 1, 1921 (Clausen); from Tokyo, Japan, 1 female, November 21, 1921 (King). Retained in the collection of the Japanese Beetle Laboratory: One female, Hangchow, China, August 19, 1924, S2; 1 male, Kuliang, China (Jen). Deposited in the collection of the Illinois Natural History Survey: One female, Hangchow, China, September 4, 1924, Y3; 1 male, Kuliang, China (Jen). Deposited in the British Museum: One female, Ningpo, China, July 27, 1925 (Jaynes); 1 male, Kuliang, China (Jen). Deposited in the Philadelphia Academy of Natural Sciences: One female, Ningpo, China, September 11, 1925; 1 male, Kuliang, China (Jen).

A number of males were collected at Kuliang, China, together with females of *inconspicua*, and were associated with the females on the basis of this fact and of the unquestionably close resemblance to *phyllophagae* paralleling the resemblance between the females of these two species.

23. TIPHIA NERVIDIRECTA, new species

Female.—Vertex strongly shagreened; primary punctures of second-degree density between the ocelli, but elsewhere of third-degree density, with an area just posterior to ocellar triangle not more densely punctate than area on either side; sparse secondaries on lateral vertex. Front strongly shagreened, with very regular, round punctures; groove interrupted; primary punctures barely of first-degree density on the anterior half, where they are not denser medially, of third-degree density above, without symmetrical impunctate areas. Clypeal extension with its impunctate margin half as long as the clypeoantennal distance. Pronotum shagreened; primary punctures in the well-defined discal band and in a small medial patch of first-degree density, those on lateral disks of sparse third-degree density; secondary punctures sparse apico-medially, not present on disks; punctate area medially much narrower than the impunctate. Side of pronotum with a pronounced groove across the center. Metanotum with numerous primary punctures nearly as large as those of the scutellum. Legs with the major calcarium of the hind tibia widest at the bend near the middle; hind basitarsus with groove, on outside with row of three long spines, one of which is apical. Tegulae faintly shagreened. Propodeal areola shaped like the cross section of a biconcave lens, two and one-quarter times as long as wide; carinae bordered by crenulate grooves interrupted by many transverse ridges; median carina extending to lowest tenth of areola; enclosed areas conspicuously shagreened. Lower portion of sides of propodeum polished, striate, with dense, minute hairs on posterior half. Posterior aspect of propodeum with median carina on lower half bordered and capped by coriaceous sculpturing. First tergite with its preapical band consisting medially of a single row of very regular punctures, expanded laterally without coalescence of punctures. First sternite with lateral grooves on posterior half having small, shallow punctures anteriorly. Tergites 2 to 4 with impunctate margin slightly wider medially, where it is three to four times the width of adjacent primary punctures. Pygidium reticulo-punctate on upper three-fifths, rather sparsely so toward middle; impunctate apical section plainly shagreened and wrinkled longitudinally and about the posterior margin. Length, 9 mm.

Male.—Not known.

Distribution.—Chekiang, China.

Type.—Cat. No. 41792, U.S.N.M. Female, Hangchow, China, July, 1925 (Jaynes).

Paratype.—One female, from the same lot as the type, in the collection of the Japanese Beetle Laboratory.

The female of this species has the following characters, by which it can be separated readily from the female of the closely related *inconspicua:* The medial patch of dense primary punctures on the vertex is lacking, but the secondary punctures on the lateral portion of vertex are more numerous; the latero-apical process of the metasternite is not bidentate on the surface facing the hind coxa; the second intercubital vein is straight, or at least not acutely bent near the middle, and joins the radius at a point as far from the wing base as its posterior origin in the cubitus.

24. TIPHIA MALAYANA Cameron

Tiphia malayana CAMERON, Entom. Runds., 27 Jahr, p. 130, 1910.
Tiphia sp. no. 114 KING, ALLEN, and HALLOCK, Journ. Econ. Ent., vol. 20, p. 371, 1927.

Female.—Vertex with primary punctures largely of third-degree density, with medial patch slightly denser than patches on either side; several minute punctures on medial line near posterior declivity. Front slightly shagreened on lower half; usually no carina or impunctate stripe; primary punctures of first-degree density from eye to eye on lower third and upward to vertex along inner orbits, of third-degree density in front of ocelli, everywhere regular in spacing. The length of the impunctate margin of the clypeal extension nearly one-half as great as the clypeoantennal distance. Antenna with the third joint distinctly shorter than its greatest width; flagellum fulvous beneath. Pronotum with the primary punctures of uniform size and well differentiated from secondaries, of first-degree density except for small latero-discal spots; transverse discal band not differentiated. Side of pronotum with a deep, continuous groove across the center, but lacking other conspicuous sculpturing. Metanotum with the largest punctures much finer than those of the sctutellum. Legs with major calcarium of hind tibiae distinctly widest at bend near middle; hind basitarsus with a shallow groove half the length of joint, outside with a row of three long, lanceolate spines, of which one is apical. Tegula red to black, rarely transparent; inner posterior angle produced and densely pilose, with several sub-erect hairs arising above the tegulae when viewed from across the dorsum. Wings faintly smoky; stigma more than twice as long as wide, extending laterally in broad curve from junction with radius. Propodeal areola slightly convergent, distinctly keystone-shaped, from two to two and one-half times as long as wide; carinae sharp and narrow, bordered with well developed grooves; median carina extending nine-tenths the distance to transverse carina. Lower portion of side of propodeum shagreened, usually with a large patch of very minute, dense hairs.

Posterior aspect of propodeum with median carina flattened, bordered by shallow impressions, and extending to the transverse carina. First abdominal tergite with the apical band consisting of punctures about one row wide at the center, widening at the sides into a depressed patch of coalesced punctures. First sternite with lateral groove on posterior three-fourths; other fourth coriaceous; disk lacking the usual dense, minute punctures. Tergites with preapical setigerous punctures becoming subdiscal medially where impunctate apex is at least four times width of nearby primary punctures; a row of minute punctures appearing on sides, but not on dorsum back of the preapical setigerous row of punctures. Pygidium uniformly reticulo-punctate on basal half; apex scarcely wrinkled. Length, 7.5 to 10.5 mm.

Male.—Vertex with primary puncture in dorso-medial patch of first-degree density. Front strongly shagreened; preocellar area on upper half with primary punctures of regular second-degree and third-degree density and with interspaces much broader than ocellus; secondary punctures nearly lacking, though primaries gradually diminish in size toward base of antennae. Antennocular distance less than the width of antennal fossa. Clypeal extension with its apical width slightly greater than the clypeoantennal distance; disk flat but protruding; apex distinctly roundly emarginate, with thick punctate margin. Flagellum often broadly infuscated beneath. Pronotum faintly shagreened; primary punctures small, and largely of third-degree density; several secondary punctures antero-medially. Side of pronotum striate, with strong groove, more or less interrupted by diagonal rugulae, crossing center in a broad curve; no punctures. Mesepisternum conspicuously shagreened; primary punctures diminishing in size and density away from the prepectus, everywhere of third-degree density; secondary punctures conspicuously less numerous than primaries over a vaguely defined area in center anterior to spiracle. Scutellum without impunctate apex as wide as the lowest primary punctures. Metanotum variable. Tibiae and femora sometimes partially reddish. Tegulà polished and faintly shagreened, varying from transparent reddish to opaque black. Wings sub-hyaline, with radial cell exceeding second cubital cell in apical extension. Propodeum with its transverse carina extending far forward medially; areola about one and one-fourth times as long as wide, its sides slightly convergent, the lateral carinae somewhat crenulate on the outer border, the medial carina tapering to apex which is situated just before transverse carina; inclosed area flat, granulate; lower portion of sides of propodeum densely striate, not finely hairy or punctate; posterior aspect densely hairy, punctate except on the conspicuous, polished, impunctate spots above, with a median carina present on lower half

or less. First tergite with preapical band narrow, usually abruptly impressed on the anterior margin and with the punctures differentiated only on the posterior border. First sternite with the posterior fossa weakly crenulate, disk polished, impunctate, with the lateral grooves extending forward a variable distance, sometimes to anterior apex; constricted portion with an elongate median keel. Tergites 3 to 5 with punctures not clearly outlined, apical ones larger than the more densely grouped anterior ones; impunctate margins at most about three times as wide as width of largest adjacent primary punctures. Length, 5 to 7 mm.

Distribution.—Borneo; Fukien, Chekiang, and Kiangsu, China; Keikido, Chosen.

The descriptive notes on the female and the description of the male are based on a selected specimen of male from Kuliang, China, 1926 (Jen), placed in the United States National Museum and on the following specimens in the collection of the Japanese Beetle Laboratory: From Suigen, Chosen, 1 female, June 3, 1922 (King), King No. 9; 1 female, April 30, 1924 (Sato), No. 6; 2 females, May 1, 1924 (Sato), Clausen No. 1857; 1 female, May 1, 1924 (Sato), No. 6. From Chinkiang, China, 2 females, July 2 and 7, 1924, Nos. B and P; 6 males, July 4 to 7, 1924 (Jaynes); 1 male, July 7, 1924 (Illingworth; 1 male, July 7, 1924; 7 females July 7 to 12, 1924 (Jaynes); 8 females, July 20 to 26, 1924 (Illingworth), " ex. hedge "; 1 female, July 28, 1924, No. 0; 1 female, August 4, 1924, No. 37; 1 female, No. 3; 1 female, June 24, 1925 (Jaynes); 160 females, China, 1925, Riverton Exp. No. 120. From Hangchow, China, 100 females, April 5 to June 9, 1925 (Chao); 17 females, April 14 to May 11, 1926 (Jaynes); 7 females, May 5 to 14, 1926 (Chao). From Kuling, China, 14 females, May 15 to June 25, 1926 (Wong); 1 female, August 21, 1926 (Wong). From Kuliang, China, 1 female, June 20, 1925, No. A1; 3 males, August 4 to 16, 1926; 24 males, 1926 (Jen). From Yangchow, China, 1 female, August 14, 1924 (Wong). Representative specimens have been deposited in the collections of the United States National Museum, the British Museum, the Philadelphia Academy of Natural Sciences, and the Illinois Natural History Survey.

Our concept of the species is based on females from our collection compared with the type female from Borneo in the British Museum by Mr. Gahan, who writes that he could see no difference except in size, the type being larger. This species has been referred to in the notes and articles published by the workers of the Japanese Beetle Project as Jaynes No. 114, Clausen No. 1857, King No. 9, and Rohwer No. 10. The association of sexes in this species was made from collecting data, males and females having been taken together at Chinkiang, China, under circumstances indicating that they were of the same species.

25. TIPHIA BREVISTIGMA, new species

Female.—Closely resembles *malayana*, but differs from it, according to our descriptive notes, as follows: Punctures of vertex largely of first-degree or second-degree density, with several rather broad, irregular, impunctate interspaces; the group of minute punctures on the medio-dorsal line lacking. Third antennal joint slightly longer than its greatest width. Pronotum shagreened. Metanotum broadly impunctate anteriorly. Groove on hind basitarsus vestigial, scarcely half the length of joint. Stigma truncate at apex, less than twice as long as wide, with radius fused with it at its apex. Median carina of the posterior aspect of the propodeum confined to its lower third and not bordered with grooves. Preapical band of first tergite not impressed laterally. First sternite not coriaceous on its constricted base; lateral grooves plainly complete to escutcheon. Length, 8 mm.

This species seems to be allied to *compressa*, from which it may be separated readily by the difference in size and the absence of the unusual diagonally longitudinal carinae present on the dorsum of the propodeum in *compressa*.

Male.—Not known.

Distribution.—Assam, India.

Holotype.—Cat. No. 41794, U.S.N.M. Female, Shillong, India.

26. TIPHIA COMPRESSA Smith

Tiphia compressa SMITH, Cat. Hymen. Brit. Mus., pt. 3, p. 82, 1855.

Female.—Vertex with a few punctures of first-degree density just back of ocelli; farther back, with punctures of third-degree density, laterally nearly impunctate. Front with pronounced impunctate stripe and interrupted groove; primary punctures very large, densest above antennae, but of first-degree density in all parts except a limited area below ocelli. Clypeal extension impunctate for nearly half the distance from its apex to base of antennae. Flagellum of antenna fulvous beneath. Pronotum polished; its primary punctures very large, and of first-degree density in all parts except a small area antero-medially to which the small, sparse secondaries are confined; discal band not well defined; medially, the punctate area distinctly narrower than the impunctate. Side of pronotum with a shallow, curved groove extending about half way across the middle, with numerous widely separated punctures on the upper half. Metanotum with its sparse primaries nearly as large as those of scutellum. Legs with major calcarium of hind tibia tapering gradually from the base; hind basitarsus with vestigial groove scarcely one-fifth length of joint and becoming shallower apically; on outside with group of three to four long, curved spines, with one at apex. Wings with first cubital mark vaguely defined. Propodeal

areola vase-shaped in outline, two times as long as wide, with five longitudinal carinae, lateral carinae without bordering grooves, median carina complete or extending to lowest eighth of areola, bordered by two sinuous carinae which extend only to lower half or third. On dorso-propodeum at either side of areola there occurs a vague diagonal carina, and just anterior to the lateral terminus of the transverse carina there is an unusual carinate angle. Lower portions of sides of propodeum finely striate; with very fine, dense hairs on posterior half. Upper portion of side with its longitudinal rugae unusually sharp and regular. Posterior aspect of propodeum scarcely coriaceous laterally, with sparse, small primaries on upper half; median carina complete, flattened, and marked by bordering grooves. First abdominal tergite with preapical band consisting of a single row of regular, well separated punctures, laterally somewhat vaguely expanded and impressed. First sternite very flat, smooth, and free from primary punctures, with lateral groove on posterior third. Tergites 3 to 5 with impunctate margins not equal to average diameter of larger adjacent primary punctures. Pygidium densely punctate on basal three-fifths, apex not wrinkled, except at sides, but strongly shagreened. Length, 12 to 13 mm.

Male.—Not known.

Distribution.—Fukien, China (type, China; restricted locality not known); Philippines.

Of the 6 females from Kuliang, China, collected August 16 to October 10, 1926 (Jen), single specimens have been deposited in the collections of the United States National Museum, the British Museum, the Illinois Natural History Survey, and the Philadelphia Academy of Natural Sciences, and two are retained in the collection of the Japanese Beetle Laboratory.

The descriptive notes were made from the specimens listed above. This material was first identified from Gahan's notes on the type in the British Museum and from his excellent figure of the highly characteristic dorsal propodeum. One of the above specimens was later compared with the type by Doctor Waterston, who verified our determination. Waterston says, however, that the type is a little larger than our specimens, and Gahan says that the tibiae are more or less reddish.

27. TIPHIA BICARINATA Cameron

Plate 1, figs. 2, 5, 7; plate 2, fig. 11; plate 3, fig. 24

Tiphia bicarinata CAMERON, Entomologist, vol. 35, p. 239, 1902.

Female.—Vertex with its irregular impunctate spaces somewhat elevated above the general surface, primary punctures of first-degree density in patches near upper eye and between ocelli, elsewhere of

second-degree density. Front perceptibly shagreened below, with a short, irregular, impunctate stripe and a very distinct narrow carina having a well defined groove on its apex; primary punctures elongated toward ocelli, irregularly distributed toward the vertex, much denser and more evenly distributed on the lower half, denser medially than toward the eyes; combined area of the punctures exceeding that of their interspaces over the greater part of front. Clypeal extension with its primary punctures mixed with minute secondaries which extend irregularly nearly to apex, leaving no well defined impunctate apex. Antenna with its first joint sharply angulate apico-ventrally; third joint slightly longer than the greatest width. Pronotum with transverse carina complete and very strongly developed; primary punctures very large, their posterior margins sloping out to surface, evenly distributed, their total area much exceeding that of the interspaces; secondary punctures very sparsely and widely distributed; transverse discal band lacking; median longitudinal extension of the punctate area about equal to that of the impunctate area. Side of pronotum usually with a very shallow, scarcely perceptible groove across the center, which is, however, somewhat more conspicuously marked than the irregular grooves or striae above and below the central groove; punctures more or less distinctly separated in a wide band just behind the carina; a round, deeply concave spot near the alar angle bordered anteriorly by concentric ridges. Scutum with the notauli and antero-medial grooves continuous. Mesepisternum with a premarginal crease, (not a groove), on its posterior slope. Metanotum usually divided by a shallow medial depression; densely bipunctate, the primary punctures nearly as large as those of the scutellum. Legs with the major calcarium of the hind tibia widest just before middle; hind basitarsus with a very deep, long groove; outside with a group of two to several sharp, stout spines, one of which is apical. Tegula usually partially shagreened; latero-anterior border with vague impression, hind border with raised edge, in front of which there is often an oval, shallowly impressed area more clearly defined laterally. Wings moderately smoky; first cubital mark usually quite conspicuously developed. Propodeal areola keystone-shaped, two times as long as wide, the enclosed area somewhat reticulate; median carina sometimes complete but usually more or less broken. Lower portion of sides of propodeum polished, striate, with posterior half minutely setulo-punctate. Posterior aspect of propodeum sparsely punctate on disk; carina tapering abruptly, and confined to lower half or less. First tergite with a preapical band of a single, well differentiated row of primary punctures. First sternite flat, polished, and without sculpturing save a few large punctures on anterior sides dwindling rapidly towards rear; no lateral grooves.

Intermediate tergites with apical rows of punctures closely parallel to apex, and bearing even rows of coarse yellow hairs; sternites with similar apical rows. Pygidium black, rugose-recticulate at base, the rugae parallel on apical half and extending to tip, apical half not faintly wrinkled and impunctate as is usual in other species. Hypopygium with a narrow medial impunctate stripe on lower half. Length, 11–14 mm.

Male.—Vertex with primary punctures back of and between ocelli of first-degree density. Front with very distinct impunctate stripe, becoming carinate anteriorly; densely covered on upper three-fourths with primary punctures which are deep, irregular, elongated upward, and separated by spaces much less than width of punctures; no preocellar region of sparse punctures; secondary punctures sparse, ascending higher on sides than medially, confined to lower third or less. Antennocular distance greater than width of antennal fossa. Clypeal extension with its width four-fifths the clypeoantennal distance; apex moderately emarginate; impunctate margin lacking. Pronotum with punctures large and deep, mostly of first-degree density, rugoso-punctate toward carina, with a tendency toward grouping in rows of four and five and to the formation of polygonal outlines where crowded; secondary punctures not present; side of pronotum with wide, polished sulca across the middle, sometimes interrupted by low, diagonal rugae. Mesepisternum with center of disk not shagreened, primary punctures very large, deep, and clearly outlined, of first-degree density; secondary punctures well differentiated, less abundant than the primaries, at least on apex of convexity; line along the posterior border impressed but not incised. Scutellum with impunctate apex not as wide as largest apical primary punctures. Metanotum with coarse primary punctures somewhat smaller than the largest on the scutellum, combined area of punctures exceeding the area of their interspaces. Tegula obscurely shagreened, with a heavy, marginal impressed line about the outside border, sometimes interupted or even lacking altogether. Wings with first cubital mark very distinct; radial cell not equaling second cell in apical extension. Propodeum with the areola scarcely longer than wide, its sides strongly convergent, the bordering carinae higher posteriorly; median carina of areola present on upper two-thirds or less; enclosed area flat, and usually polished; disk of dorsum outside of areola sparsely coarse-punctate; lower portion of sides striate, without minute hairs posteriorly; posterior aspect strongly concave, with median disk sharply bipunctate and median carina present on lower half or less. First tergite with preapical band narrowing to a single, close-set row of coarse punctures which are not sunk in a depression.

First sternite with extremely fine punctures on disk, and coarser ones toward apex; lateral groove on posterior half or less, often absent, anterior half with median punctate process but without the usual keel. Tergites not shagreened, with coarse punctures terminating in even rows, removed from apices by distances scarcely exceeding the width of the punctures; tergites 2 to 6 with apical rows of coarse brown hairs; marginal incised line complete over dorsum; sternites 2 to 5 with conspicuous apical rows of brown hairs; fifth sternite with lateral process weakly developed or altogether absent. Length, 9 to 10.5 mm.

Distribution.—Japan; Keikido, Chosen; Fukien, China.

The description of the male and the descriptive notes on the female are based on a selected male specimen from Suigen, Chosen, insectary reared, Jap. Beetle Par. Exp. No. 335, and the following specimens in the collection of the Japanese Beetle Laboratory: From Kowai, Japan, 1 female, August 1926. From Suigen, Chosen, 1 male, May 10, 1923 (Clausen); 1 female, August 10, 1924 (Sato), Clausen No. 1860; 1 female, August 15, 1925 (Sato), Gardner No. 15; 2 females, August 19, 1926 (Gardner); 3 males and 1 female, August 23, 1926, Exp. 210 (Gardner); 1 female, August 26, 1926 (Gardner); 1 female, August 29, 1926, Exp. 210 (Gardner); 24 females, August 1924 (Gardner), Gardner No. 15; 17 males and 27 females, insectary reared, Riverton Exp. 210, 1926; 29 males and 3 females, insectary reared, Riverton Exp. 335, 1927; 1 male, insectary reared, Exp. 335, August 9, 1927; 6 males, insectary reared, August, 1927; 2 females, insectary reared, Riverton Exp. 310, 1927; 1 female, insectary reared, Riverton Exp. 316; 2 females, insectary reared, August 1927; 1 male Gardner No. 15. From Kuliang, China, 2 females. August 16, 1926 (Jen), and 1 male, 1926 (Jen).

One additional female, Suigen, Chosen, August 19, 1925 (Clausen) Rohwer No. 11, placed here although it varies from the typical form in having no impunctate stripe on hypopygium. The specimens from China are very poor, and are not suitable for a thorough comparison. They vary slightly from the other material, but if they are not of this species they are exceedingly close to it. Representative specimens have been deposited in the collections of the United States National Museum, the British Museum, the Illinois Natural History Survey, and the Philadelphia Academy of Natural Sciences.

Specimens in our collection from Suigen, Chosen, were compared with the type in the British Museum by Gahan and Waterston, both of whom consider them to be of the same species. The type is labelled "Japan, 21.7.81. (Cameron coll. 1901–261.)" It is a female, although in the original description it is listed as a male. This

species has been known to the workers of the Japanese Beetle Laboratory as Clausen No. 1860 and Gardner No. 15. Rohwer has designated it by his species No. 11. The association of sexes is based on rearing records. Females have been taken in the field in large numbers in Chosen, and are represented in our collection by specimens collected by Gardner and labelled "Gardner No. 15." Their progeny have been reared, emerging in New Jersey (Exps. Nos. 210 and 335).

28. TIPHIA BREVILINEATA, new species

Female.—Vertex with primary punctures of first-degree density in irregular patches near upper eye, of second degree between and behind ocelli, and of third degree on either side with intervening spaces nearly impunctate. Front polished; carina and impunctate stripe scarcely differentiated; groove usually well developed; primary punctures of first-degree density from eye to eye on lower third and along inner orbits inward toward ocelli, below ocelli of third-degree density, with vague impunctate areas. Clypeus with its primary punctures interspersed with minute punctures extending nearly to apex, leaving no well-defined impunctate margin. Mandibles with short, shallow medial groove. Antenna with its first joint sharply angulate apico-ventrally. Pronotum with its transverse carina complete and very strongly developed; primary punctures of first-degree density just back of the carina and in the fairly well-differentiated transverse discal band, of third degree on lateral disk, and with secondary punctures lacking or very sparse; medial longitudinal extension of punctate area distinctly less than that of impunctate area. Side of pronotum with indistinct sculpturing across the center, primary and secondary punctures sparsely scattered over the anterior third and along the dorsal margin; a deep auricular depression at the alar angle. Scutum with its notauli and its antero-medial groove continuous. Mesepisternum with a vague premarginal crease on its posterior slope. Metanotum with its coarse punctures nearly equalling those of scutellum. Legs with major calcarium of hind tibia distinctly widest at the bend near the middle; hind basitarsus with the groove pronounced, its outside spines principally in rows of three, broadly lanceolate, one apical. Tegula considerably longer than broad, inner hind angle slightly produced. Propodeal areola variable in outline, one and one-half to two times as long as wide; carinae without pronounced bordering grooves; median carina weakest at middle, nearly or quite complete; enclosed area reticulate apically. Lower portion of sides of propodeum polished, striate, with a small but well-defined setigerous patch. Posterior aspect of propodeum weakly coriaceous at the

sides and above; median carina varying from poorly developed to nearly complete. First abdominal tergite with a preapical band consisting of a well-differentiated single row of punctures in a narrow depression. First sternite flat, without lateral groove; sparse, deep punctures anteriorly. Tergites 4 and 5 without impunctate apices of greater width than nearby primary punctures. Pygidum deeply rugose-punctate, with many sharp, black, longitudinal ridges extending to the extreme apex. Hypopygium with very narrow median impunctate stripe confined to the apical third or less. Length, 8.5 to 13 mm.

Male.—Not known.

Distribution.—Keikido, Chosen.

Type.—Cat. No. 41796, U.S.N.M. Female, Suigen, Chosen, July, 1926 (Gardner), Gardner No. 9.

Paratypes.—All females from Suigen, Chosen. In the United States National Museum: One, July 1, 1927, Gardner No. 9. In the collection of the Illinois Natural History Survey: One, July 1926 (Gardner), Gardner No. 9. In the collection of the Philadelphia Academy of Natural Sciences: One, July 3, 1925 (Sato), Gardner No. 9. In the collection of the British Museum: One, July 5, 1925 (Sato), Gardner No. 9. Retained in the collection of the Japanese Beetle Laboratory: One, July 5, 1925 (Sato), Gardner No. 9.

This species has been known to the workers of the Japanese Beetle Project as Gardner No. 9.

29. TIPHIA CILICINCTA, new species

Male.—Vertex with a well-defined medial patch of primary punctures scarcely of first-degree density. Front with a low, linear, medial carina; primary punctures unusually large, round, and clearly outlined, with preocellar region large and having several interspaces as broad as ocelli; secondary punctures inconspicuous but present medially on lowest fourth. Antennocular distance less than width of antennal fossa. Clypeal extension with its apical width scarcely exceeded by clypeoantennal distance; apex shallowly emarginate, densely punctate to the thick margin; disk flattened. Pronotum with its punctures rather uniformly and sparsely of second-degree or third-degree density; secondary punctures lacking. Side of pronotum rather smooth and polished, with an interrupted groove extending in a broad curve from the border of the transverse carina to the rather densely punctate alar angle. Mesepisternum with clearly outlined primary punctures of third-degree density, their interspaces, excepting those of the posterior aspect and of the anterio-dorsal corner, with a very few, minute secondary punctures which are less

numerous than the primaries. Scutellum with impunctate apex narrower than width of apical primary punctures. Metanotum impunctate medially, elsewhere densely bipunctate, the primary punctures scarcely half as large as the largest of the scutellum. Tegula shagreened, without abruptly thickened margins. Wings hyaline; radial cell far exceeding second cubital cell; first cubital mark outlined by distinct folds and sometimes by a distinct spur arising from the first abscissa of the radius. Propodeal areola with curved, convergent lateral carinae which do not become higher as they approach the apex, length of areola scarcely exceeding its basal width, median carina inflated, usually terminating before apex of areola, enclosed area coarsely reticulate; lower portion of sides faintly striate, without perceptible hairs; posterior aspect smoothly and finely setulopunctate, without a median carina. Preapical band of first tergite present, sometimes with its anterior border abruptly impressed, at least for part of its length, rather wide though constricted at center, with numerous coalesced punctures, but always with a row or partial row of deep, well-separated primary punctures on posterior border. First sternite distinctly bipunctate, with a moderate number of fine, setulose punctures on disk; lateral groove continuous to escutcheon, anterio-medial keel present. Tergites 2 to 5 with apical rows of uniformly round, deep punctures, and bearing very dark, coarse hairs which are arranged in an even row; impunctate margins obsolete. Sternites 2 to 5 with apical rows similar to those of the dorsum but even more conspicuously developed. Sternal denticles lacking. Length, 8.5 to 9.5 mm.

Female.—Not known.

Distribution.—Fukien, China.

Type.—Cat. No. 41797, U.S.N.M. Male, Kuliang, China, August 27, 1926.

Paratypes.—All males, Kuliang, China. Retained in the collection of the Japanese Beetle Laboratory: One, August 30, 1926. Deposited in the collection of the British Museum: One, August 28, 1926. In the collections of the Illinois Natural History Survey and the Philadelphia Academy of Natural Sciences: One each, labeled August 25, 1926. Deposited in the United States National Museum: Three, 1926 (Jen).

30. TIPHIA FUKIENSIS, new species

Plate 2, fig. 10

Male.—Vertex with primary punctures of nearly first-degree density in a patch behind the ocellar triangle and beside the eyes, intervening space nearly impunctate. Front shagreened, with a median linear impression extending nearly to ocellus; primary punc-

tures large, round, very clearly outlined, their average diameter on the lower front much greater than the average interspace; preocellar area large, with several interspaces nearly as broad as an ocellus; a few minute secondary punctures on lowest fourth. Antennocular distance slightly less than width of antennal fossa. Clypeal extension with its apical width about equal to the clypeoantennal distance; apex shallowly emarginate, with a thick, widely impunctate margin. Pronotum strongly shagreened; punctures of second-degree or third-degree density, regularly spaced, without trace of a transverse discal band; secondary punctures lacking. Side of pronotum finely striate, with a pronounced central groove interrupted by fine rugulae, and extending in a broad curve to the densely punctate alar angle. Mesepisternum with rather sparse, clearly outlined primary punctures; secondaries somewhat more numerous than the primaries in a median belt, above and below which they are almost lacking. Scutellum with impunctate apex narrower than the apical primary punctures. Metanotum sparsely and uniformly bipunctate, the larger primary punctures nearly equalling those of the scutellum. Tegula conspicuously shagreened, with an abruptly thickened, polished margin which is widest at the lateral posterior angle. Wings hyaline; radial cell far exceeding the second cubital cell; first cubital mark plainly outlined by fuscous tracings. Propodeum with its areola parallel-sided, scarcely longer than wide, median carina complete; transverse carina angulate at each junction with the longitudinal carinae, the junction with the lateral carinae located distinctly posterior to the junction with the median carina, inclosed area finely coriaceous; lower sides faintly striate, with a large patch of microscopic hairs; posterior aspect polished above, without median carina. First tergite vaguely concave in region of the preapical band, which consists of an irregular series of distinctly separated round punctures, and which has its anterior margin sometimes abruptly impressed at the sides. First sternite polished on posterior portion, shallowly punctate to coriaceous on anterior half, with lateral grooves on posterior half or less and again on constricted anterior portion, median keel broad and low. Tergites 2 to 5 with uniform apical rows of deep, round punctures, each tergite bearing an even row of coarse, brown cilia, and abruptly terminated behind these rows, without impunctate margins. Sternites 2 to 5 with apical rows of coarse hairs similar to those of tergites; fifth sternite with vestigal denticles on the sides. Length, 10 to 11 mm.

Female.—Not known.

Distribution.—Fukien, China.

Type.—Cat. No. 41798, U.S.N.M. Male, Kuliang, China (Jen).

Paratype.—A male from the same lot, retained in the collection of the Japanese Beetle Laboratory.

31. TIPHIA ASERICAE, new species

Female.—Vertex with a few series of primary punctures of second-degree density extending through and behind ocellar triangle, primaries denser medially than on either side. Front highly polished; groove present, though frequently interrupted; primary punctures sparse, denser on anterior third, where they are evenly distributed between the eyes, chiefly of second-degree density, except broadly on median upper front, where density is of third degree. Impunctate apex of clypeal extension poorly defined by an irregular row of coarse punctures, its longitudinal extension about one-third the distance from apex of clypeus to base of antennae. Flagellum of antenna fulvous beneath. Pronotum with its primary punctures nearly uniform in size; no definite transverse discal row or medial patch of punctures; secondary punctures sparse but well differentiated, widely scattered; medial longitudinal extension of punctate area slightly less than that of impunctate area. Side of pronotum without a groove across the center, but with striations in this region sometimes increased to short, shallow, irregular grooves. Scutum with its notauli and its antero-medial groove continuous or nearly so. Metanotum densely bipunctate on its periphery, with its largest discal punctures much smaller than those of the scutellum. Legs with major calcarium of hind tibia widest at bend near middle; hind basitarsus with groove, shallow and extending about one-half the length of joint, a group of three lanceolate spines on outside, one of which is apical. Tegula thin, red, polished, transparent. Wings slightly smoky. Propodeal areola almost rectangular, two and one-half to three times as long as wide; carinae narrow and uniform, bordered by conspicuous grooves; median carina on lowest three-fourths or complete. Lower portion of sides of propodeum shagreened, with patch of microscopic, appressed hairs. Posterior aspect of propodeum usually with scattered punctures antero-medially; median carina weak and flattened, sometimes complete. First abdominal tergite with well-developed preapical band of coalesced punctures in deep, narrow groove abruptly depressed on anterior border. First sternite with lateral groove on posterior half, and a few scattered punctures anteriorly. Tergites with polished impunctate margins medially about 3 to 4 times the width of largest bordering punctures. Pygidium uniformly reticulo-punctate on basal half, with polished, impunctate emargination; apex scarcely wrinkled, and not shagreened. Length, 8 to 8.5 mm.

Male.—Vertex with primary punctures everywhere of third-degree density. Front with rather small primary punctures, lacking usual patch of punctures on lower front; preocellar patch on upper half

very wide, with primary punctures of irregular second-degree and third-degree density and with interspaces broader than an ocellus; secondary punctures very dense below, not well differentiated from primaries on bipunctate area, ascending half way to lowest ocellus medially and about one-third of the way along eyes. Antennocular distance about equal to the width of antennal fossa. Clypeal extension with its apical width four-fifths the clypeoantennal distance; disk flat and not protruding; apex shallowly emarginate, lacking an impunctate margin, but with a thick edge. Pronotum with primary punctures small, fairly well outlined, largely of third-degree density; a few secondary punctures close to carina. Side of pronotum finely striate, without a definite medial groove. Mesepisternum with small, sparse, well-outlined primary punctures; secondary punctures dense on upper half and bordering the prepectus and posterior margin, less numerous than primaries only on the small callosity above the coxa; no premarginal groove, though appearing shallowly impressed in certain lights. Scutellum, except medially, with impunctate apex not as wide as largest apical primary punctures. Metanotum with dense secondary punctures apically, elsewhere with sparse primaries nearly equaling the largest of the scutellum in size. Tibiae and tarsi of first two pairs of legs mostly reddish. Tegula polished, translucent, red. Wings with radial cell slightly exceeding cubital cell. Propodeum with areola rectangular in outline, nearly twice as long as wide, lateral carinae without bordering groove, the median carina sinuous, the inclosed area somewhat rugose. Side with lower region not punctate or hairy but finely shagreened; posterior aspect densely hairy and punctate, with a median carina on lower half.

First tergite with preapical band narrow, deeply impressed, of nearly uniform width, its punctures fading out on surface of depression. First sternite with lateral groove on posterior third; disk with vague punctures and a sharp median keel anteriorly. Tergites 3 to 5 moderately shagreened, with punctures extending to apex. Fifth sternite with its lateral denticle appearing more like a crescent than a tooth. Length, 6.5 mm.

Distribution.—Keikido, Chosen; Iwate, Japan; Chekiang, China.

Type and allotype.—Cat. No. 41799, U.S.N.M. Type, female, and allotype, male, Suigen, Chosen, June 5, 1924 (Sato), Clausen No. 1859.

Paratypes.—All females. In the National Museum: From Suigen, Chosen, 19, June 5, 1924 (Sato), Clausen No. 1859; 1, June 5, 1924 (Sato), Gardner No. 8; 3, June 15, 1925 (Sato), Gardner No. 8; 2, June, 1925 (Gardner), Gardner No. 8, equals Clausen No. 1859. From Hangchow, China, 1, July, 1925 (Jaynes). From Kowai, Japan, 3, August, 1926. To the collections of the British Museum,

the Illinois Natural History Survey, the Philadelphia Academy of Natural Sciences, and the Japanese Beetle Laboratory: Two to each from Suigen, Chosen, June 5, 1924 (Sato), Clausen No. 1859.

Two females and one male, Koriyama, Japan, June 14, 1920 (Clausen), varying towards *agilis*, were deposited at the United States National Museum but were excluded from the type series. The specimens from China and Japan differ very slightly from the form from Chosen in having the preapical band less linear and less deeply impressed across the medio-dorsum. The association of male with female was made by Mr. Clausen, and is based on rearing work done in Chosen. This species has been known to the men in Japanese Beetle parasite work as Clausen No. 1859 and Gardner No. 8.

32. TIPHIA AGILIS Smith

Tiphia agilis SMITH, Trans. Ent. Soc. London, 1873, p. 184.

This species was identified by Mr. Gahan after comparison of a male in our collection from Suigen, Chosen, with the type male in the British Museum. The female is identical with *asericae* in all characters used in our description, except that the side of the pronotum has a shallow, narrow, interrupted groove across its center, and that the length is slightly less, being 7.5 to 8.5 mm.

The male is characterized as follows: Vertex with primary punctures in a dorsal, medial patch, of first-degree density. Front faintly shagreened; preocellar area irregularly beset with primary punctures and with several interspaces as broad as the lowest ocellus; secondary punctures not well differentiated, a few ascending medially half way to ocellus, but not nearly so high beside the eyes. Antennocular distance equal to width of antennal fossa. Clypeoantennal distance one and one-fourth times width of clypeal extension at apex; punctures of extension continuous to the margin, which is slightly emarginate and not flattened. Flagellum broadly reddened beneath. Pronotum with small, poorly outlined primary punctures, of third-degree density outside the anterior medial patch; secondary punctures not apparent. Side of pronotum broadly striate, with irregular depression across the center interrupted by numerous rugae. Mesepisternum with primary punctures shallow and of sparse third-degree density; secondary punctures everywhere more numerous than primaries, except in a narrow area on the median surface between mesocoxa and tegula. Metanotum densely punctate, with punctures considerably finer than the coarsest punctures of the scutellum. Tibia and apices of femora of the first two pairs of legs red. Tegula reddish and semitransparent, except at base. Wings hyaline, with radial cell slightly exceeding second cubital cell.

Propodeal areola subrectangular; lower portion of side polished, shagreened, with barely perceptible hairs posteriorly; posterior aspect inconspicuously coriaceous, with the median carina faintly developed on lower half or less. First tergite with its preapical band abruptly impressed on anterior border, not much expanded laterally, marked posteriorly by a moderately regular row of clearly outlined primaries. First sternite with lateral grooves on posterior half and a faint median keel anteriorly. Tergites 3 to 5 with rather fine, poorly outlined punctures; impunctate margin medially scarcely three times width of largest adjacent primary punctures. Length, 5 to 6.5 mm.

The male differs from *asericae* in having the preapical band wider and shallower, with its posterior punctures much less coalesced, and from *malayana* in having the front, mesepisternum, and tergites less strongly shagreened, the punctures of the median vertical patch denser and less clearly outlined, the primaries of the mesepisternum less numerous, the secondaries more numerous, and the radial cell less conspicuously extended.

Distribution.—Hyogo, Kanagawa, and Iwate, Japan; Keikido, Chosen; Fukien, China.

The foregoing notes are based upon a selected female specimen from Suigen, Chosen, July 25, 1923 (Sato), Clausen No. 1852, not reared, and on the following specimens in the collection of the United States National Museum and the Japanese Beetle Laboratory: From Yokohama, Japan, 8 females, May 17, 1920 (Clausen), Clausen No. 1382; 1 male, September 15, 1921 (Clausen). From Morioka, Japan, 3 females and 3 males, August 20, 1920 (Clausen). From Kowai, Japan, 4 females, August, 1926. From Koriyama, Japan, 3 females, June 14, 1920 (Clausen). From Suigen, Chosen, 4 females, August 8, 17, and 21, 1922 (King); 5 females, July 25, 1923 (Sato), Clausen No. 1852; 7 females, August, 1923 (Clausen); 2 females, August 10 and 12, 1924 (Gardner), Gardner No. 1 equals Clausen No. 1852; 23 females, August, 1925 (Gardner), used in breeding, Gardner No. 1; 1 female, August 12, 1925 (Sato), Gardner No. 1; 1 female, September 6, 1925 (Sato), Gardner No. 1; 3 females and 1 male, insectary reared, Riverton Exp. 214; 4 females and 2 males, insectary reared, Riverton Exp. 314. From Kuliang, China, 1 female, August 6, 1925, labelled F 1.

Representative specimens have been deposited in the collections of the British Museum, the Illinois Natural History Survey, and the Philadelphia Academy of Natural Sciences. The association of sexes is the result of breeding work. The specimens in Riverton experiment 214 were derived from field-collected females from Suigen, August, 1925, and those in Riverton experiment 314 were derived

from females taken in the same locality in 1926. This species has been known to workers of the Japanese Beetle Project as Clausen No. 1852 and as Gardner No. 1. In the specimens from Kowai, Japan, the median carina of the propodeal areola is present only on the upper half, while in the Chosen form it is usually developed on the upper four-fifths. The females collected by Clausen at Suigen, Chosen, August, 1923, differ from the others in having the tibiae wholly red and the femora broadly castaneous on the inner surface. Although the adults of this species vary but slightly from *asericae*, the biological characters determined by Clausen and Gardner in Chosen serve to distinguish it quite clearly from the latter.

33. TIPHIA VERNALIS Rohwer

Plate 1, fig. 6; Plate 2, fig. 16; Plate 3, fig. 19; Plate 4, figs. 25, 29

Tiphia vernalis ROHWER, Proc. Ent. Soc. Wash., vol. 26, p. 91, 1924.—KING and HALLOCK, Journ. Econ. Ent., vol. 18, p. 356, 1925.—CLAUSEN, KING, and TERANISHI, U. S. Dept. of Agr., Dept. Bull. 1429, p. 40, fig. 28, 1927.—KING, ALLEN, and HALLOCK, Journ. Econ. Ent., vol. 20, p. 369, 1927.

The following descriptive notes are supplementary to the original description.

Female.—Vertex with a broad, median patch of minute punctures extending forward on dorsum for a short distance from the occipital region. Clypeus with its lateral margin nearly straight. Mandibles without an uninterrupted median groove. Punctate portion of the pronotum distinctly narrower at its middle than the impunctate apex; impunctate apex medially, usually with from one to three or more short, indistinct, longitudinal grooves. Metanotum usually with a sparsely bipunctate, shallow, median impression, with its coarser punctures nearly as large as those of the scutellum. Legs with major calcarium of the hind tibia broadest just before the middle; hind basitarsus on the outside with a row of three lanceolate spines, one of which is at apex. First tergite with a small medial patch of minute punctures on anterior slope. Lateral grooves of first sternite present on posterior half or less. Tergites 2 to 4 with wide, impunctate apices, medially at least one-fifth as wide as the punctate portion; no trace of a row of vestigial apical punctures or of a marginal linear groove over the dorsum. Pygidium reticulo-punctate on basal two-fifths, the impunctate apex wrinkled but not shagreened; the punctate portion with a well-marked impunctate emargination.

Male.—Vertex usually invaded from behind by dense, minute punctures scattered over an area wider than ocellar triangle. Preocellar area of front with its widest interspaces not quite as wide as an

ocellus; lower front with primary punctures gradually diminishing in size, but without a well-defined bipunctate area. Antennocular distance less than width of antennal fossa. Clypeal extension protruding, with a convex disk; clypeoantennal distance nearly twice the apical width of the clypeal extension. Mesepisternum with primary punctures large and clearly outlined; the secondary punctures sparser than the primaries except on the posterior slope. Apex of scutellum impunctate or minutely punctate, distinctly wider than the lower primaries. Primary punctures of metanotum as large as those of the scutellum. Median carina of the posterior aspect of propodeum usually complete to the upper transverse carina. First tergite with a wide preapical band which is not in a depression, and which consists of large, well separated punctures. First sternite with a polished impunctate disk, a crenulate apical fossa, and numerous deep punctures anteriorly, but lacking a lateral groove or a definite antero-medial keel. Tergites 3 to 5 with impunctate apices as wide at the center as six times the diameter of largest adjacent primary punctures. Hypopygium with its impunctate median stripe widening caudally, and bordered by a tuft of dense, erect, white hairs. Genitalia, in ventral aspect, with the outer clasper abruptly constricted near the middle, the outer edge nearly straight, the inner angle broadly crenulate; second genital segment with the apical hook broadly spatulate, the inner hind margin sloping abruptly, without marked convexity or angles; distal portion of aedeagus with the apical lobes very slender, much narrower than the broad lateral processes; proximal portion of aedeagus tapering gradually from near base toward constriction.

Distribution.—Keikido, Chosen; Musashi, Kanagawa, Japan; Kiangsu, Kiangsi, and Chekiang, China.

The above descriptive notes are based on a study of the type series including specimens of both sexes from Suigen, Chosen, and Oiso, Japan, in the United States National Museum, and of the following specimens in the collection of the United States National Museum and the Japanese Beetle Laboratory: From Yokohama, Japan, 1 female and 2 males, April 24 and 25, 1921 (King); 1 female, May 1, 1921 (King); 2 males, May 5, 1921 (King). From Suigen, Chosen, 5 females, June 15, 1923 (King); 2 females, May 25, 1924 (Sato), No. 7; 3 females and 37 males, reared, Riverton, 1925, Exp. 28; 2 males, May 20, 1926 (Gardner); 170 females, May 15–30, 1926 (Gardner); 2 females and 1 male, insectary reared, Riverton No. 230. From Asakawa, Japan, 1 female, June 15, 1920 (Clausen), Clausen No. 1380, Roh. No. 4. From Kuling, China, 1 male and 12 females, May 15–June 23, 1926 (Wong). From Sungkiang, China, 20 males,

April 30–May 5. 1926 (Ren). From Yehzah, China, 1 male, April 28, 1926 (Ren). From Hangchow, China, 1 female, April 24, 1925 (Chao); 1 female, May 15, 1925 (Chao); 2 females, 1925; 1 male and 2 females, April 14, 1926 (Jaynes); 1 male, April 19, 1926 (Chao); 35 females, April 15–May 13, 1926 (Chao); 1 female, April 29, 1926 (Jaynes), Exp. Nos. 204–3; 2 females, Exp. 120; 7 females, May 5–9, 1926 (Chao). From Zakow, China, 3 males and 37 females. No labels, 5 males and 1 female. Representative specimens have been deposited in the collections of the British Museum, the Illinois Natural History Survey, and the Philadelphia Academy of Natural Sciences. In the collection of the United States National Museum, 3 females, Asakawa, Japan, June 15, 1920 (Clausen), Clausen No. 1380, Rohwer No. 4 have been referred to this species.

Nearly all the material from Suigen, Chosen, and much of that collected early in May, 1926, by Chao at Hangchow, China, is marked by having grooves on the medio-dorsum of the impunctate apex of the pronotum, by having directly above the antennal fossae a group of 30 or more punctures which are much larger, more angular, and closer together than the others, with linear interspaces, and by having the bend in the first abscissa of the radius distinct and nearly or quite equal to one-third the distance to the first intercubital vein, and with the second intercubital vein strongly bent at the middle. Nearly all the specimens from Zakow, China, and some from Hangchow, China, which were collected on the same dates as the above, differ in being noticeably smaller, in lacking the median groove on the pronotum, in having the punctures immediately above the antennal fossae scarcely larger than others on the front, and with a cluster of at most one dozen crowded and angulate punctures with linear interspaces, in lacking the distinct bend of the first abscissa of the radius, which, if present, is scarcely more than one-fourth the distance to the first intercubital vein, and with the second intercubital vein nearly straight. Between the two extremes there are specimens from a number of localities which show many degrees of intergradation. For this reason, and because all available biological data show no striking differences among the forms included here, it has been decided to include all forms within the same species.

In two males, one without a label and the other from Hangchow, China, April 15, 1924 (Chao), the clypeal extension is more nearly truncate, and is scarcely half as wide apically as the clypeoantennal distance. The impression on the outside of the tegula does not end as abruptly as in the specimens from Chosen, and the punctures of the preocellar area are noticeably sparse. However, these specimens should probably be considered as mere variations from the typical *vernalis*.

34. TIPHIA MATURA, new species [1]

Female.—Vertex strongly shagreened; punctures of first-degree density occurring in patches behind ocellar triangle and near eye orbits, the broad, irregular intervening space impunctate except for several sparse secondary punctures; minute punctures extending forward from occipital area toward ocellar triangle in a narrow, interrupted band. Front shagreened, with faint carina, well-developed median groove, and impunctate stripe; primary punctures very large and clearly outlined, everywhere of first degree density except on medial stripe, but densest below, where interspaces average much less than the average diameter of primary punctures. Clypeal extension with its impunctate margin of uniform longitudinal extension, it being two-fifths as great as the clypeoantennal distance. Pronotum with its transverse carina lacking over a considerable part of the dorsum; primary punctures of uniform first-degree density over most of the area, though slightly sparser on lateral disks; no trace of transverse discal band; secondary punctures sparsely distributed; the impunctate area medially, slightly narrower than the punctate. Sides of pronotum with a strong, straight central groove, uninterrupted except for minute rugulae jutting from the upper margin. Metanotum coarsely bipunctate, its primary punctures more than half as large as the largest of the scutellum. Metasternum with its posterior lateral angles single, in slender points which curve backward at the tips; no depression along the suture; disks sparsely punctate. Major calcarium of hind tibia widest at the bend near the middle; hind basitarsus with a longitudinal groove, and with a group of three or four stout, black, lanceolate spines on the outside, of which one is at the apex. Tegula shagreened. Wings very smoky; second intercubital vein straight, except for a rounded angle at the junction with the radius; stigma small, less than twice as long as broad, joined by radius near its middle. Propodeum with areola subrectangular, twice as long as wide, its carinae of uniform height and width, and bordered by vague grooves; median carina complete or nearly so. Lower portion of sides of propodeum mostly covered by a patch of dense, minute setigerous punctures. Posterior aspect uniformly setulose and feebly coriaceous; median carina flat and low, ranging from present on the lower half only to complete; transverse carina behind the areola densely minute punctate. First tergite with a well-defined preapical band widening toward the sides from a single row at the center, its punctures rather uniform in size and tending to coalesce with each other laterally, the band separated from apex of the tergite by a wide, polished margin. First sternite without sculp-

[1] See *Tiphia* No. 2036, King, Allen, and Hallock, Journ. Econ. Ent., vol. 20, p. 371, 1927.

turing, except for lateral grooves on posterior half, which are sometimes continued anteriorly by irregular, interrupted gouges. Tergites with wide impunctate belts across their middles interrupted medially by sparse punctures; impunctate apices at least one-fourth the punctate width of the tergite. Pygidium rugoso-punctate on upper half; impunctate apex strongly wrinkled and shagreened. Length, 9.5 to 11 mm.

Male.—Vertex with punctures of first-degree density between and behind ocelli forming a well-defined patch on either side of which are nearly impunctate areas crossed by a series of punctures of second-degree density. Front obscurely shagreened, with a vague, medial impunctate stripe; primary punctures rather small, and very densely distributed over lower front and extending on to the preocellar region, and leaving no impunctate interspaces as broad as an ocellus; secondary punctures scarcely as numerous as primaries, extending upward over lower half laterally, but rising higher on center, where they nearly reach the lowest ocellus. Antennocular distance much less than width of antennal fossa. Clypeal extension with its width two-thirds the clypeoantennal distance; apex masked with appressed hairs, acutely emarginate, only the two extreme apical points impunctate. Pronotum with punctures small, shallow, without distinct outlines and largely of third-degree density, without much tendency toward rows; secondary punctures present antero-medially, though difficult to distinguish; side of pronotum weakly striate, with a tapering median groove crossed by diagonal rugulae. Mesepisternum with primary punctures large and not clearly outlined, of first-degree density on upper disk, becoming thinner behind and below; secondary punctures almost lacking, except on posterior slope. Scutellum with impunctate apex not as wide as the lowest primary punctures. Metanotum densely and coarsely punctate, the primary punctures nearly as large as the largest of the scutellum and covering an area exceeding that of the interspaces. Wings hyaline; radial cell exceeding second cubital cell. Propodeum with its areola slightly longer than wide, with moderately converging sides, enclosed area and disk outside of areola reticulate; side, on its lower portion, polished anteriorly, minutely setulose posteriorly; posterior aspect granulate, the median carina complete or nearly so. First tergite with a preapical band having an irregular, impressed anterior border and separate punctures of nearly uniform width on posterior border. First sternite with impunctate, polished disk, coriaceous to sparsely punctate anteriorly, lateral grooves on posterior half, median keel on upper half. Tergites 3 to 5 with punctures sparse, with indefinite hind margins, and with impunctate apex medially six times the diameter of largest adjacent primary puncture. Length, 9 mm.

Distribution.—Assam, India.

Type and allotype.—Cat. No. 41801, U.S.N.M. Type, female, and allotype, male, Shillong, India, Jap. Beetle Par. Exp. 433.

Paratypes.—Deposited in the U. S. National Museum: Thirty-one females and 12 males, Shillong, India, Jap. Beetle Par. Exp. 433. Retained in the collection of the Japanese Beetle Laboratory, and deposited in the collections of the British Museum, the Illinois Natural History Survey, and the Philadelphia Academy of Natural Sciences: Two females and 1 male of the same lot to each.

Several females in a lot from Shillong, India, 1926 (Clausen), have the areola somewhat more slender, being slightly over twice as long as wide; otherwise they are like the type.

The association of the sexes has been made through breeding. The specimens labeled " Exp. 433 " were obtained at the Japanese Beetle Laboratory from cocoons, which in turn were obtained from progeny of field-collected females at Shillong. This species has been referred to in notes and papers of the Japanese Beetle Laboratory as Clausen No. 2036.

35. TIPHIA PULLIVORA, new species [2]

Female.—Vertex with primary punctures densest between ocelli, back of ocellar triangle, and between it and the eyes, where they are mostly of second-degree density, very sparse on either side of median patch. Front faintly shagreened on lower half, with impunctate stripe scarcely perceptible; primary punctures densest on lower half, where they are evenly distributed between the eyes, mostly of first-degree density, on upper front mostly of third-degree density without pronounced impunctate spots; hairs on lower half directed strongly outward. Clypeus with its lateral margin slightly convex; length of impunctate margin of clypeal extension nearly equal to one-half the clypeoantennae distance. Pronotum with its primary punctures of uniform size and well differentiated from the secondaries, slightly more numerous at center than on lateral disks; no transverse discal band. Metanotum with vague medial impression, bipunctate, the coarser punctures smaller than those of scutellum. Legs with major calcarium of hind tibia tapering from base; hind basitarsus with two modified spurs on outside, one of them at apex, groove moderately deep, and half the length of joint. Wings faintly smoky. Propodeal areola keystone-shaped, sides slightly convergent, one and one-half times as long as wide, carinae without bordering grooves; median carina on upper two-thirds or more. Lower portion of sides of propodeum faintly striate, with posterior patch of very minute hairs. Posterior aspect of propodeum without sculpturing save the usual lateral coriaceous area, and a poorly defined

[2] See *Tiphia* No. 2049, King, Allen, and Hallock, Journ. Econ. Ent., vol. 20, p. 370, 1927.

carina on the lower half or less. Preapical band with a single row of closely set but well separated punctures distally, its impression abruptly outlined anteriorly. First sternite polished, without sculpturing except lateral grooves on posterior quarter or less. Tergites 3 to 5 with impunctate apices wider at the middle, where they are at least one-fourth the width of the punctate portion of the tergite. Pygidium uniformly punctate on basal three-fifths, with a large, impunctate emargination; impunctate apex wrinkled, but not shagreened. Length, 6.5 to 7.5 mm.

Male.—Vertex with a small, wedge-shaped invasion of minute punctures from the posterior slope; primary punctures everywhere of third-degree density. Front conspicuously shagreened; punctures of preocellar area of third-degree density with several impunctate spots as broad as an ocellus; secondary punctures rather poorly defined, though as abundant as the primaries in the area to which they are limited, that is, the lowest third directly above the antennal fossae. Antennocular distance equal to about the width of antennal fossa. Clypeal extension with its apical width four-fifths the clypeo-antennal distance; apex shallowly emarginate, with a very narrow impunctate margin. Pronotum with dorsum shagreened; primary punctures with poorly defined margins, and of uniform third-degree density; secondary punctures not very distinct, largely confined to antero-medial region. Side of pronotum faintly striate, without a groove across the center, and almost free of sculpturing. Mesepisternum shagreened; primary punctures small and not clearly outlined, of third-degree density; secondary punctures on upper half somewhat more numerous, thinning out ventrally. Scutellum with impunctate apex, at places wider than the lowest primary punctures. Metanotum with primary punctures barely of first-degree density and nearly as large as the largest of the scutellum. Wings hyaline, with radial cell equalling, or slightly exceeding second cubital cell. Propodeum with areola scarcely one and one-quarter times as long as wide, outline subrectangular, the median carina usually ending before apex of areola; enclosed area flat and shagreened; upper portion of side with its parallel rugae very fine and disappearing posteriorly; lower portion of side shagreened, not densely hairy; posterior aspect with median carina confined to lower half, and uniformly clothed with dense, fine, poorly outlined, setulose punctures. First tergite highly polished, with only sparse, fine punctures medially; preapical band in a broad depression, with its punctures widely separated. First sternite with lateral grooves on posterior fourth; disk polished, impunctate, anterior half sparsely and shallowly punctate, with a pronounced median keel. Tergites 3 to 5 with their punctures fine, rather sparse, with poorly defined margins; impunctate margin me-

dially four to six times the diameter of largest adjacent primary punctures. Length, 6.5 mm.

Distribution.—Assam, India.

Type and allotype.—Cat. No. 41802, U.S.N.M. Type, female, and allotype, male, Shillong, India, Jap. Beetle Par. Exp. 302–0.

Paratypes.—All from Shillong, India. Deposited in the U. S. National Museum: One female and 3 males, Jap. Beetle Par. Exp. 202; 3 females and 45 males, Jap. Beetle Par. Exp. 302–0; 6 females and 25 males. Retained in the collection of the Japanese Beetle Laboratory: One female and 2 males, Jap. Beetle Par. Exp. 302–0. Deposited in the collections of the British Museum, the Illinois Natural History Survey, and the Philadelphia Academy of Natural Sciences: In each, 1 female and 2 males of the same lot as the last.

The association of the sexes has been made through the rearing of adults from field-collected cocoons obtained at Shillong (Exps. 202 and 302–0). The males corresponded in abundance and in time of emergence with the females. There were three other species reared from this material, but in very much smaller numbers and at a different time of the year.

This species has been known to workers of the Japanese Beetle Project as Clausen No. 2049.

36. TIPHIA BISECULATA, new species [3]

Plate 4, figs. 30 and 31

Female.—Vertex with primary punctures of second-degree density delimiting irregular impunctate spaces. Punctures slightly denser medially than on either side. Front polished, with broad impunctate stripe extending up to ocellus; carina and groove usually absent; primary punctures with tendency toward arrangement in irregular rows, frequently with two, and at places more interspaces, exceeding diameter of punctures; preocellar area with several interspaces as broad as ocellus. Clypeal extension with clearly defined impunctate apex, the longitudinal extension of which equals two-fifths the distance from apex of clypeus to base of antennae. Flagellum of antenna fulvous beneath. Pronotum with its transverse carina usually complete, though weakly developed; primary punctures of uniform size, and well differentiated from secondaries, much denser medially and in transverse discal band than on lateral disks; secondary punctures numerous medially; punctate portion medially slightly narrower than the impunctate portion. Side of pronotum broadly and weakly striate, usually with one barely perceptible groove in the middle equal to one-half the length of the sclerite, and with numer-

[3] See *Tiphia* No. 1851. King, Allen, and Hallock, Journ. Econ. Ent., vol. 20, p. 369, 1927.

ous, scattered, round punctures mostly above the middle. Scutum with its notauli and its anterior medial groove continuous or nearly so. Metanotum with shallow median impression, densely punctate, its largest punctures nearly equalling those of the scutellum. Legs with femora and tibiae of last two pairs bright red; major calcarium of hind tibia widest at bend near middle; groove of hind basitarsus deep, and nearly as long as the joint; outside spines of basitarsus stoutly lanceolate, irregular, from three to seven in number including one at apex. Tegula with outer edge thin and somewhat upcurled. Propodeal areola keystone to vase-shaped in outline, from two to two and one-half times as long as wide; carina not bordered by grooves or transverse ridges, frequently lacking in part; medial carina somewhat broader than lateral carina, and complete; inclosed area apically sometimes reticulate. Lower portion of sides of propodeum minutely striate, not clearly separated from the upper rugose area. Posterior aspect of propodeum glossily setulose at center; narrow medial carina complete to the transverse carina, except for occasional interruptions. First tergite usually with a small, elongate median patch of dense, fine punctures; preapical band not differentiated. First sternite with a lateral groove on posterior half; anterior half with sparse punctures. Tergites with minute, nonsetigerous punctures in a broken line just before the apices; impunctate apex at the middle from five to six times the width of largest bordering punctures. Pygidium densely reticulo-punctate on basal three-fifths; apex wrinkled, outside wrinkles converging along the margin; impunctate area very faintly shagreened at the sides; impunctate emargination very small. Length, 7.5 to 11.5 mm.

Male.—Vertex with primary punctures everywhere of third-degree density. Front with carina and impunctate stripe; primary punctures densely grouped on lower front, preocellar area with punctures irregularly spaced on upper half, with several interspaces as broad as an ocellus; secondary punctures very fine, and more numerous than primaries on lowest third, ascending medially slightly higher than near the eyes. Antennocular distance greater than width of antennal fossa. Clypeal extension with the apical width four-fifths the clypeoantennal distance; disk convex; apex shallowly emarginate, with narrow but well-defined impunctate margin, apical points upturned. Pronotum with its transverse carina produced into a prominent angle laterally; primary punctures very small, obscurely outlined, and largely of sparse third-degree density; secondary punctures widely distributed over punctate area, but difficult to distinguish from the primaries. Side striate, with anastomosing rugae anteriorly, but without a distinct groove across the center. Mesepisternum with small, fairly well outlined punctures

of third-degree density; secondary punctures fairly well differentiated, and everywhere much more numerous than the primaries. Scutellum with impunctate apex not as wide as the posterior primary punctures. Metanotum unusually convex, with primary punctures of first-degree density nearly as large as those of the scutellum. Tegula with a very fine, marginal, impressed line. Wings with the radial cell not equaling the second cubital cell. Propodeum with its areola strongly convergent, and from one and one-half to two times as long as wide, longitudinal carinae highest at apex of areola, not bordered by grooves, median carina usually nearly complete, broader than the laterals, inclosed area granular-reticulate; lower portion of sides densely shagreened and not perceptibly hairy; posterior aspect granulate, its median carina usually lacking. First tergite with its preapical band wide, poorly defined, in a broad, scarcely perceptible depression, with the punctures distinctly separated. First sternite with deeply crenulate apical fossa, lateral grooves on posterior third, and distinctly bipunctate, with dense secondary punctures covering the disk. Tergites 3 to 5 with vaguely outlined punctures; impunctate margins at center as much as five times width of the largest adjacent primary punctures. Denticle on fifth sternite small, with its raised edge more nearly parallel to margin than to longitudinal plane. Length, 6.5 to 8 mm.

Distribution.—Shizuoka, Japan.

Type and allotype.—Cat. No. 41803, U.S.N.M. Type, female, Miho, Japan, October 1, 1926, and allotype, male, Miho, Japan, insectary reared.

Paratypes.—All from Miho, Japan. In the collection of the National Museum: Four males and 3 females, June 13, 1920 (Clausen), Clausen No. 1381, Rohwer No. 2; 1 male and 2 females, June 18, 1920 (Clausen), Clausen No. 1381, Rohwer No. 2; 8 females, October 4, 1924 (Ouchi), Clausen No. 1851, Rohwer No. 2; 16 males and 5 females, insectary reared; 6 females, September, 1926 (Gardner), Clausen No. 1851; 198 females, October 1, 1926, 2 males and 18 females, Exp. 303, 1927. Retained in the collection of the Japanese Beetle Laboratory: Four females, October 1, 1926, and 4 males, insectary reared. Deposited in the collections of the British Museum, the Illinois Natural History Survey, and the Philadelphia Academy of Natural Sciences: Four females to each, October 1, 1926, and 1 male to each, insectary reared.

The sexes have been associated through breeding. Specimens labeled "insectary reared" and "Exp. 303" emerged at the Japanese Beetle Laboratory from cocoons shipped from field stations in the Orient. The cocoons were obtained from progeny of field-collected females which are represented in our collection by the series collected

by Gardner in September, 1926. This species has for some time been known to the workers of the Japanese Beetle Project as Clausen No. 1851 and as the "Japanese red-legged Tiphia."

37. TIPHIA PIGMENTATA, new species

Female.—Vertex with primary punctures of first-degree density behind ocelli, laterally almost impunctate in spots. Front faintly shagreened below; groove present; primary punctures medium in size, of first-degree density only narrowly along inner orbits and beside ocellar triangle, elsewhere of second-degree or third-degree density; preocellar area broad, with several interspaces twice as broad as an ocellus. Clypeal extension emarginate; the impunctate apex limited by a definite row of punctures, its longitudinal extension two-fifths the distance from apex of clypeus to base of antennae. Flagellum of antenna fulvous beneath. Pronotum with transverse carina with broad lacuna dorso-medially, and with primary punctures of first-degree density in antero-medial patch and in a well-defined transverse discal band, of third-degree density, and very sparse on lateral disks; secondary punctures few and widely scattered; medial width of punctate area medially considerably narrower than the impunctate area. Side of pronotum with a somewhat interrupted and variable groove across the center, above which there are scarcely any primary punctures. Metanotum with vague median impression; its rather sparse primary punctures nearly as large as the primaries of the scutellum. Legs black, except the femora of the last two pairs, which are bright red; major calcarium of the hind tibia widest near the middle, where there is a very distinct bend; hind basitarsus with a short, shallow groove and a row of three lanceolate spines on the outside, of which one is at apex. Tegula black to bright reddish, but not thin or transparent. Propodeal areaola shaped like the cross section of a biconcave lens, two and one-fourth times as long as wide; carinae bordered by grooves; median carina extending to lowest eighth. Lower portion of sides of propodeum faintly striate, densely and minutely setulo-punctate on posterior half. Posterior aspect of propodeum with flattened linear carina on lowest three-fifths or more. First tergite with its preapical band of regularly spaced punctures one row wide at center, more or less irregularly expanded at sides, where the anterior margin is somewhat abruptly impressed. First sternite with lateral grooves, which may be interrupted anteriorly, on posterior half; front third shallowly coriaceous to sparsely punctate. Medially, the impunctate margins of the intermediate tergites about six times the width of the largest adjacent primary punctures. Pygidium densely rugoso-punctate on basal half; apex not wrinkled, excepting very faintly

at the sides; the impunctate emargination very broad, usually shagreened. Length, 8 to 10 mm.

Male.—Not known.

Distribution.—Chekiang and Kiangsu, China.

Type.—Cat. No. 41804, U.S.N.M. Female, Zakow, China, June 9, 1925 (Chao), No. 5X.

Paratypes.—All females. Retained in the collection of the Japanese Beetle Laboratory: One Zakow, China, June 5, 1924 (Jaynes). In the collection of the Illinois Natural History Survey: One, Zakow, China, July 23, 1924 (Chao), No. W. In the British Museum: One, Zakow, China, June 9, 1925 (Chao), No. 5W. In the U. S. National Museum: One, Chinkiang, China, July 10, 1924, No. G.

This species bears a superficial resemblance to *biseculata*, from which it may readily be distinguished by the characters given in the key, the sparser punctation of the front, by the presence of a parallel-sided areola having its lateral carinae bordered by grooves, by the lack of minute punctures on the anterio-median region of the first tergite, by the strong tendency of the apical primary punctures of the intermediate tergites to be grouped in transverse bands, and by the presence of a much broader impunctate emargination of the punctate portion of the pygidium.

38. TIPHIA CLAUSENI, new species

Female.—Vertex between, beside, and directly behind the rear ocelli with primary punctures of second-degree density, and irregular impunctate areas on either side of the medial patch. Front with punctations of uniform density on lower half medially and along inner orbits of eyes to vertex, with vague, nearly impunctate areas obliquely below ocellar triangle, with numerous interspaces on upper half as broad as an ocellus. Clypeus with its lateral margin slightly convex; extension with length of its impunctate apex two-fifths the clypeoantennal distance. Pronotum with its transverse carina nearly lacking across the dorsum; primary punctures slightly larger in the poorly defined discal band than elsewhere, and slightly denser medially than on the lateral disks, of first-degree density except on the disks, where they are of third degree; secondary punctures lacking; longitudinal extension of punctate area medially about equal to impunctate, though a small emargination gives the impunctate apex the appearance of being longer. Side of pronotum with a median groove extending nearly to alar angle, but interrupted on upper side by many minute rugae. Metathorax sparsely punctate, the punctures much smaller than the primary punctures of the scutellum. Legs with major calcarium of hind tibia widest at the pronounced bend near the middle; hind basitarsus with groove, on outside with row of

three pricklelike spines, one of which is apical. Prododeal areola subrectangular, from two and one-half to three times as long as wide; carinae bordered by well defined grooves; median carina complete to lowest sixth or more. Lower portion of side of propodeum polished, striate, with barely perceptible hairs on posterior half. Posterior aspect of propodeum with its carina linear, flattened on the top, and complete. First tergite with preapical band of a single row of well separated punctures at center, expanding laterally to coalesced patches in which the anterior edge is abruptly impressed. First sternite with lateral grooves extending, with frequent interruptions, to near anterior apex; disk almost bare, highly polished, with strongly light-reflecting medial convexity. Tergites 2 to 4 rather finely punctate, with broad, nearly impunctate discal spaces; impunctate apices medially many times as wide as the largest adjacent primary punctures. Pygidium finely and densely reticulo-punctate on the basal half; impunctate emargination very broad; apical impunctate portion not perceptibly wrinkled. Stylet sheath and palps usually not extruding beyond tip of abdomen when in repose. Length, 8 to 9 mm.

Male.—Not known.

Distribution.—Assam, India.

Type.—Cat. No. 41805, U.S.N.M. Female, Cherrapunji, Assam, India, April, 1926 (Clausen).

Paratypes.—In the collections of the National Museum, the British Museum, the Illinois Natural History Survey, the Philadelphia Academy of Natural Sciences, and the Japanese Beetle Laboratory: One each of the same lot as the type.

This species closely resembles the Zakow series of *vernalis*, but differs in the following characters: It has no patch of minute punctures dorso-medially on the vertex; the mesonotum lacks the median impression and has finer punctures, the first tergite lacks the medial patch of dense, minute punctures, the impunctate apices of the intermediate tergites are wider, and the impunctate apex of the pygidium is not wrinkled. The species is apparently closely related to *pigmentata* also, and differs from it in having black legs, in the denser punctation of the front, the deeper, more frequently interrupted central groove of the side of the pronotum, and the finer punctures of the metanotum and the intermediate tergites. The specimen in the Japanese Beetle Laboratory has the lateral and medial grooves of the scutum continuous.

39. TIPHIA LONGITEGULATA, new species

Female.—Vertex with punctures of second-degree and third-degree density, not denser medially. Front with its impunctate stripe poorly defined; primary punctures very sparse above, much

denser on lower half, where they are evenly distributed and of first-degree density between the eyes. Clypeus with its lateral margin convex; extension decidedly truncate and usually red; longitudinal extension of impunctate apex equal to two-fifths the distance from apex of clypeus to base of antennae. Antenna with the apex of the first joint, the entire second and third joints, and the central portion of the other joints reddish brown. Pronotum with its primary punctures rather sparse, especially on lateral disk; transverse discal band not clearly differentiated; secondary punctures absent or nearly so; medial extension of the punctate area about equal to that of the impunctate area. Side of pronotum usually with a groove across the center which is often surrounded by shorter, shallower grooves or irregular punctures which make it inconspicuous. Scutum with its notauli and its anterior medial grooves continuous. Scutellum with a broad, shallow groove on the sides. Metanotum with minute punctures on its borders much smaller than those of scutellum. Legs with the tarsi and apices of tibiae reddish; major calcarium of hind tibia tapering both ways from near middle; hind basitarsus with a very short, shallow groove, and outside with three short, lanceolate spines, one at apex. Tegula red, transparent, highly polished, two times as long as wide, with inner hind corner conspicuously produced. Wings slightly smoky. Propodeal areola rectangular in outline, twice as long as wide, carinae high and uniform, with well developed bordering grooves; median carina on upper three-fourths; enclosed area flat and finely granulate. Lower portion of sides of propodeum striate. Posterior aspect of propodeum faintly coriaceous along upper margin; median carina usually absent. First tergite with a well-defined preapical band, sometimes interrupted in center, but expanded into a patch on each side, abruptly depressed anteriorly. First sternite with faint, diagonal wrinkles apically; disk not sculptured; lateral grooves extending to anterior apex. Tergites with very shallow punctures. Pygidium densely and uniformly punctate on basal half; impunctate apex scarcely wrinkled. Length, 7 to 7.5 mm.

Male.—Vertex with punctures back of ocelli of sparse third-degree density, scarcely denser than on the sides of the vertex. Front with its preocellar area wide and deep, with wide impunctate interspaces nearly twice the width of an ocellus; secondary punctures not apparent. Antennocular distance about equal to width of antennal fossa. Clypeus abruptly tilted at an angle to the plane of the face; extension with its margin truncate, broadly impunctate, sometimes reddish, its apical width scarcely equal to the clypeoantennal distance. Antenna with the apex of the pedicel and the flagellum beneath reddish. Pronotum sparsely coarse-punctate, with primary punctures of third-degree density; area back of transverse carina with unusually

long, sharply defined crenulae. Sides of pronotum irregularly rugose-striate, with a central groove not well differentiated from the striae. Mesepisternum with round punctures having clear outlines, of sparse third-degree density; almost devoid of secondary punctures on outer upper disk; posterior border with a premarginal groove. Scutellum with impunctate apex not as wide as the lowest primary punctures. Metanotum sparsely punctate, the punctures not nearly as large as the largest of the scutellum. Tibiae and tarsi partially reddish. Tegula twice as long as wide, very thin, semitransparent, and reddish at the margin. Wings hyaline; radial cell somewhat exceeding the second cubital cell. Propodeum with its areola strongly convergent, the bordering carinae strongest at its apex, the median carina usually confined to the upper half, the inclosed area strongly reticulate; posterior aspect without definite medial carina. First tergite with a well-defined preapical band which is narrow at the center and widely expanded at the sides, the punctures not extensively coalesced. First sternite mostly polished, impunctate, with lateral grooves on posterior half and vestigial median keel anteriorly. Intermediate tergites with the punctures very small, deep, and round; the impunctate margins at most five times the width of largest adjacent primary punctures; extreme apices of tergites 3 to 6 with a vestigial row of minute non-setigerous punctures over the dorsum. Denticle with its elevated edge nearly parallel to the longitudinal plane. Length, 5 to 5.5 mm.

Distribution.—Fukien, Kiangsu, and Chekiang, China.

Type and allotype.—Cat. No. 41806 U.S.N.M. Type, female, Kuliang, China, August 29, 1926 (Jen); allotype, male, Kuliang, China, August 4, 1926.

Paratypes.—Retained in the collection of the Japanese Beetle Laboratory: One female and 1 male, Kuliang, China, August 4, 1926 (Jen). Deposited in the British Museum: One female, Kuliang, China, 1926 (Jen), and 1 male, Kuliang, China, September 8, 1926 (Jen). Deposited in the collection of the Illinois Natural History Survey: One female, Kuliang, China, 1926 (Jen). Deposited in the collection of the Philadelphia Academy of Natural Sciences: One female, Kuliang, China, 1926 (Jen). Deposited with the United States National Museum: From Kuliang, China, 1 male and 1 female, August 4 and September 27, 1926 (Jen), 1 female, August 28, 1926 (Jen), and 6 females, 1926 (Jen); from Chinkiang, China, 1 female, July 5, 1925 (Wong); from Hangchow, China, 4 females, July 11–20, 1926 (Chao).

The association of sexes in this species was made from collecting data, males and females having been collected together at Kuliang, China. This association is substantiated by the peculiar, very long tegulae which occur in both sexes. Two females and one male from

Kuliang, China, August 4, 1926 (Jen), which were determined as of this species but are not included among the paratypes because of their poor condition, are retained in the collection of the Japanese Beetle Laboratory.

40. TIPHIA LATISTRIATA, new species

Female.—Vertex with a narrow row of minute punctures extending from posterior declivous portion to the ocellar triangle; primary punctures of first-degree density back of ocelli and near upper portion of eye, with irregular, nearly impunctate intervening spaces. Front shagreened near lower part of eye, with well-developed median groove; primary punctures very irregular in size, denser on lower half, but scarcely denser medially than toward eyes; preocellar area broad, but with scarcely any interspaces as wide as an ocellus. Pronotum with its transverse ridge lacking on narrow median portion, but strongly developed laterally; primary punctures of dorsum uniform in size, and clearly differentiated from secondaries, more numerous medially and in a line just anterior to impunctate apex than on disk laterally, punctate portion medially distinctly narrower than the impunctate portion. Side of pronotum broadly and deeply rugose across center, without a well-defined median groove. Metanotum depressed at center, sparsely bipunctate, the primary punctures large, but scarcely half as large as the largest punctures on the scutellum. Legs with major calcarium of the hind tibia broadest just before center; hind basitarsus with a deep groove, outside with three or four lanceolate shaped spurs in a single row, one at apex of basitarsus. Wings faintly smoky. Propodeal areola keystone-shaped, two and one-fourth times as long as wide, carinae sharp and narrow, not bordered by grooves or transverse ridges; medial carinae usually confined to upper half or three-fifths. Lower portion of sides of propodeum fine wavy-striate, with numerous barely visible hairs posteriorly. Posterior aspect of propodeum with its median carina complete and bordered on the side by two parallel grooves. First tergite with a small, elongate patch of dense, minute punctures on its anterior slope; preapical band consisting of a single row of poorly defined, sparse punctures in a depression abruptly sunken on the anterior border. First sternite with lateral grooves on posterior half of sides; disk unsculptured, except for scattered shallow punctures on sides toward the apex. Tergites 2 to 4 with apical punctures differentiated into a definite band that is separated from the other punctures by a nearly impunctate area, and from the apex by several times the width of band at the middle. Pygidium densely and uniformly reticulo-punctate on basal three-fifths, with a small, impunctate emargination; apex conspicuously wrinkled and shagreened. Length, 11.5 mm.

Male.—Not known.

Distribution.—Keikido, Chosen; Iwate, Japan.

Type.—Cat. No. 41807, U.S.N.M. Female, Suigen, Chosen, August, 1923 (Clausen), Rohwer No. 12.

Paratypes.—Deposited in the collections of the British Museum, the Illinois Natural History Survey, the Philadelphia Academy of Natural Sciences, and the Japanese Beetle Laboratory: To each, one of the same series as the type. In the United States National Museum: Eleven additional females, Suigen, Chosen, August, 1923 (Clausen), Rohwer No. 12, and 1 female, Kowai, Japan, August, 1926.

41. TIPHIA MINUTOPUNCTATA, new species

Female.—Vertex with patch of primary punctures back of ocellar triangle denser than on either side or even between ocelli, yet of only third-degree density. Front with distinct groove; primary punctures scarcely as dense medially as on either side, largely of second-degree density, of first-degree density only narrowly along eye orbits, with numerous interspaces on upper half as broad as an ocellus. Third antennal joint distinctly longer than its greatest width. Impunctate margin of clypeal extension not defined by an even row of punctures above, its longitudinal extension about one-third the clypeoantennal distance. Pronotum with its transverse ridge complete and sharply erect at center; primary punctures somewhat larger and denser in the transverse discal band, where they are of first-degree density, elsewhere of third degree, though more sparse on lateral disks than medially; secondary punctures sparse apico-medially; punctate portion narrower medially than the impunctate. Metanotum shallowly impressed at center, with its sparse primary punctures smaller than the largest of the scutellum. Legs with major calcarium of the hind tibia widest just before middle; hind basitarsus with groove, on outside with irregular group of from six to eight stout spines, one of which is apical. Tegula with inner hind corner somewhat produced. Wings nearly hyaline. Propodeal areola rectangular, two and one-half times as long as wide; carinae bordered by grooves; median carina extending to lowest fifth. Lower portion of sides of propodeum faintly striate and densely and minutely setulo-punctate on posterior half. First tergite sometimes with patch of minute, setigerous punctures medially; preapical band of irregularly spaced but well separated punctures about two rows wide at center. First sternite with lateral grooves on posterior third, with interrupted continuations anteriorly, otherwise scarcely sculptured. Tergites 2 to 4 with the punctures medially in a well defined band which is narrower than the distance from the band to the apex, the impunctate apex medially being at least as wide as six times the diameter of the adjacent pri-

mary punctures. Pygidium densely reticulo-punctate on basal three-fifths; apical section plainly wrinkled longitudinally on either side of the impunctate emargination. Length, 11 mm.

Male.—Not known.

Distribution.—Kiangsi, China.

Type.—Cat. No. 41808, U.S.N.M. Female, Kuling, China, July 11, 1926 (Wong).

Paratype.—Retained in the collection of the Japanese Beetle Laboratory: One female of the same lot as the type.

The sting sheaths of the two specimens examined are unusually exserted to distance equal to width of pygidium, and the two associated accessory processes for nearly half the distance. Whether this condition is normal or not can not be stated, but if so it furnishes a rather good diagnostic character.

42. TIPHIA NANA, new species

Male.—Vertex with punctures small, poorly outlined, everywhere of third-degree density, though denser back of ocellar triangle and near the eyes. Front faintly shagreened below; primary punctures clearly outlined, nearly everywhere of third-degree density except near the lower eye orbits; preocellar area broad, with interspaces laterally at least twice the width of an ocellus; secondary punctures not apparent. Antennocular distance less than the width of antennal fossa. Clypeal extension with its apical width one and one-fourth times clypeoantennal distance, abruptly emarginate, sparsely coarse-punctate to apex, disk slightly convex. Pronotum with its dorsum sparsely punctate with small primary punctures of uniform third-degree density, the impunctate hind margin nearly reaching the transverse carina medially; secondary punctures lacking; side with a faint, curved groove extending two-thirds the distance to alar angle. Mesepisternum sparsely fine-punctate, with secondary punctures not clearly differentiated on the outer, convex disk. Scutellum with impunctate apex nearly as wide as the largest primary punctures. Metanotum with apical callosity, its sparse primary punctures as large as the largest on the scutellum. Wings hyaline; radial cell greatly exceeding second cubital cell. Propodeum with its areola convergent and straight-sided, length one and one-half times its width, enclosed area smooth and flat; side with its upper portion scarcely rugose, not clearly differentiated from the lower shagreened portion. First tergite with a preapical band in a shallow concavity marked posteriorly by a single row of small, poorly outlined primary punctures. First sternite not coriaceous, with lateral grooves on posterior half and a strong median keel on anterior half. Intermediate tergites faintly shagreened; the primary punctures very small

and poorly outlined; impunctate apices at middle about one-fourth the punctate width. Lateral denticle of sixth sternite very small and appressed. Length, 5.5 mm.

Female.—Not known.

Distribution.—Fukien, China.

Holotype.—Cat. No. 41809, U.S.N.M. Male, Kuliang, China, August 4, 1926 (Jen).

SUPPLEMENTARY NOTES ON TYPES OF ORIENTAL TIPHIA IN THE BRITISH MUSEUM

During the winter of 1927–28, while the work on this paper was in progress, Mr. Gahan, who at the time was in Europe examining types of Hymenoptera, was asked to compare examples of our material with the extensive collection of types in the British Museum. For this purpose, determined specimens of nearly all the species represented in the material being studied were sent to him, together with our keys to species. The junior author also had studied these types during the preceding winter, but he had none of our material with him for comparison. Though it should be pointed out that our ideas as to species have been clarified considerably since these examinations were made, and the keys upon which Gahan based his determinations have been considerably altered, the following notes are valuable as an aid in associating species previously described with species described in this paper.

TIPHIA PUNCTATA Smith

Tiphia punctata SMITH, Trans. Ent. Soc. London, 1873, p. 183.

Described from a male from Hyogo, Japan. The notes by Gahan make it clear that this species belongs to the *koreana* group, in which the first tergite has the very deep preapical groove broadly overlapped on the dorsum. It could not be *antigenata* or *communis*, since both have conspicuous, short, erect, brown pile on the tergites, while *punctata* Smith is entirely devoid of such pile, both on the tergites and on the sternites. *T. ovidorsalis* could probably be eliminated as a possibility, although the erect, brown pile in this species is much sparser, and, in some specimens, might easily be overlooked. No other males are known in this interesting group, although several of the species are known in the female sex, including two species from Japan, *tegitiplaga*, and *autumnalis*.

TIPHIA ROBUSTA Cameron

Tiphia robusta CAMERON, Ann. Mag. Nat. Hist., ser. 7, vol. 13, 1904, p. 283.

Originally described from a female, from northern India. In the British Museum there is one female, not the type, determined as of

this species and labeled Burma; whether the determination is correct is not known. The following notes by Gahan indicate that it is quite different from other species described in this paper. In our key it runs to couplet 21, but is quite different from either of the species included there. Only the hind femur is red. The pygidium is sculptured like that of *totopunctata*, although it is somewhat smoother at the apex, and is thickly studded on the punctate portion with dark colored, nearly black, long, stiff setae which are distinctly thicker and stiffer than those usually found on this tergite. The fourth and fifth tergites each have a double row of similar bristles at the apex. The forewings are unusually dark: nearly black. The first tergite has a transverse row of coarse, shallow punctures at the angle between the anterior and dorsal aspects, these punctures producing a distinct, though slightly irregular fold at the anterior margin of the tergite.

TIPHIA CLYPEALIS Cameron

Tiphia clypealis Cameron, Mem. and Proc. Manchester Lit. and Philos. Soc., vol. 41, no. 4, 1896–97, p. 47.

The type male, from Masuri, would undoubtedly run out to the *rufomandibulata-notopolita* complex, as it did in the provisional key used by Gahan. He notes that in this species the clypeus is differently colored and the body much more hairy.

TIPHIA CARBONARIA Smith

Tiphia carbonaria Smith, Journ. Proc. Linn. Soc. London, Zool., vol. 5, 1861, p. 78.

There is a female from Malaya, not marked type, in the British Museum. It would run to couplet 6 in our key, but its course from that point is uncertain. Gahan found that it differed from *rufomandibulata* in being distinctly larger, in lacking crenulae along the dorsal apex of the propodeum, in having the median carina of the propodeal areola ending abruptly just before the apex, in the more definite limitation between the upper rugose portion and the lower shagreened portion of the sides of the propodeum, and in the absence of linear marginal grooves on the tegula. The continuity of the lateral and of the anterior grooves of the scutum would separate it at once from the other species under couplet 6, including *lyrata*, *brevicarinata*, *sternocarinata*, and *notopolita*.

TIPHIA STIGMA Smith

Tiphia stigma Smith, Journ. Proc. Linn. Soc. London, Zool., vol. 2, 1858, p. 91.

Three females from Borneo, none marked type, are in the British Museum. Gahan notes that quite possibly these represent different

species. He found that one differed from *carbonaria* only slightly, having darker wings, having the joints of the flagellum, except the last, not longer than broad, while those of *carbonaria* are all a little longer than broad, and having the punctures of the pygidium somewhat finer.

TIPHIA FUMIPENNIS Smith

Tiphia fumipennis SMITH, Journ. Proc. Linn. Soc. London, Zool., vol. 2, 1858, p. 90.

A female from Borneo, not marked type, is in the British Museum. Gahan finds that this species would run to couplet 6, and that it is like *carbonaria*, but differs markedly from it and other related species in having the ocellocular line hardly equal to twice the greatest width of an ocellus, while in other species it is three or four times as long. The ocelli appear to be unusually large and the eyes more than ordinarily convergent above. The propodeum is unusually long, being nearly, if not quite, two-thirds as long down the middle of the dorsum as broad at the apex of the dorsum. The preapical row of punctures on the first tergite is very weak, and the whole tergite is weakly punctate to a noticeable degree, with unusually small punctures; the disk of the second tergite medially from base to apex is almost impunctate except for a few sparse, very weak punctures, even the preapical row being subobsolete. Gahan's notes appear to differentiate this species quite sharply from other species discussed in this paper.

TIPHIA BORNEANA Cameron

Tiphia borneana CAMERON, Entomologist, vol. 40, 1907, p. 288.

A single male from Borneo, marked type, is in the British Museum. Gahan finds that it agrees in many characters with our specimens of *malayana*, but the following differences are noted, which undoubtedly separate it not only from *malayana* but from the other species in our keys. The radial cell is pointed at its apex, the radial vein joining the metacarpus at the margin of the wing in a sharp angle, without the usual backward or upward curve found in *malayana*. The second cubital and second recurrent veins also are more nearly interstitial. The pronotum is almost impunctate, but has a very few subobsolete punctures. The propodeum is shagreened and is similar to that of *malayana*, but lacks the crenulae or rugae bordering the transverse carina and the longitudinal carinae that form the sides of the areola. The first tergite is almost impunctate, the transverse preapical groove is present but impunctate; the second tergite is almost impunctate and is polished; the following tergites are finely shagreened, and have weak punctures.

TIPHIA AURIPENNIS Bingham

Tiphia auripennis BINGHAM, Fauna Brit. India. Hymenop., vol. 1, 1897, p. 64.

The material in the British Museum includes a female, the type of *auripennis*, and a female, the type of *curvinerva* Cameron, which is considered to be conspecific. Both are from Assam, India. Gahan states that in the key sent to him *auripennis* ran to our species *inconspicua*, and it probably would do the same in the present key. He stated, however, that it was not identical with *inconspicua*.

TIPHIA ANNANDALEI Turner

Tiphia annandalei TURNER, Ann. Mag. Nat. Hist., ser. 8, vol. 2, 1908, p. 123.

Described from the female type in the British Museum, labeled Siam; probably from Selangor, on the West Malay Peninsula. Gahan runs this species to couplet 30 of our key. He says that it resembles *phyllophagae* more or less, but has the apical half of the pygidium very strongly shagreened and with a few wrinkles (not striations as in *totopunctata*). The clypeus is squarely truncate at the apex, the truncate margin of the extension reaching a point outside the antennal fossa. The last character is quite different from any possessed by the other species included in couplet 30, namely, *nervidirecta*, *popilliavora*, *phyllophagae*, and *ovinigris*. The species is apparently different from any discussed in this paper.

TIPHIA IMPLICATA Cameron

Tiphia implicata CAMERON, Mem. and Proc. Manchester Lit. and Philos. Soc., vol. 41, no. 4, 1896–97, p. 50.

The type, a male from "Masuri," would very likely run to *popilliavora* in our key, as it did in the provisional key used by Mr. Gahan. He found that it differed from the latter in having the front more densely punctate and beset with longer and more numerous hairs.

TIPHIA FUSCINERVIS Cameron

Tiphia fuscinervis CAMERON, Mem. and Proc. Manchester Lit. and Philos. Soc., vol. 41, no. 4, 1896–97, p. 48.

Described from the female from "Mussouri." In the British Museum there are two males and one female, not labeled types, from the "Kanga Valley." Gahan considers these to be the same as our species *capillata*, as he found no differences except the following colorational variations. The tibiae are not bright red, but have a decided reddish cast. In the males, the first two pairs of tibiae are red, but the hind pair is darker. Although our species *capillata* may equal *fuscinervis*, we hesitate to state that it does without having examined the type.

TIPHIA RUFIPES Smith

Tiphia rufipes SMITH, Cat. Hymenop. Insects in Coll. Brit. Mus., pt. 3, 1855, p. 83.

The type, a female labeled "N. India," runs in our key to *capillata*, but differs in having all the femora as well as the tibiae bright red. Gahan notes also that the pygidium is nearly devoid of shagreening, while that of *capillata* is rather strongly shagreened.

TIPHIA ORDINARIA Smith

Tiphia ordinaria SMITH, Trans. Ent. Soc. London, 1873, p. 184

This species comes close to *bicarinata*, and may possibly be a variety, though it is probably another species. The type is a male from Hyogo, Japan, while the type of *bicarinata* is a female, also from Japan. It differs from our males of *bicarinata* in not having dark-colored hairs on the apical tergites, in having distinct lateral grooves on the lower half of the first sternite, and in having a radial cell exceeding the second cubital cell. An occasional specimen of our lot of *bicarinata* has lateral grooves on the lower third of the first sternite, but most have none. In *bicarinata*, the radial cell is actually only equal to the lower corner of the second cubital cell, although the oblique trend of the intercubital cell gives the radial cell the appearance of exceeding the second cubital.

TIPHIA SPINOSA Cameron

Tiphia spinosa CAMERON, Entomologist, vol. 35, 1902, p. 237

Described from a male from Khasia (Hills), India. Mr. Gahan notes that it lacks denticles and orifices on the fifth sternite, which would throw it to couplet 2 in our key, with the alternatives of *bicarinata* and *cilicincta*. The other characters mentioned by him, which serve to separate it from these species, are as follows. The first sternite, exclusive of its lateral folds, is nearly or quite twice as long as its apical width, and is entirely and coarsely rugoso-punctate, the basal half having a strong medial carina which, at its anterior end, is produced downward into a short, hooklike tooth. In *bicarinata*, the first sternite is not nearly twice as long as wide, it is finely punctate on the apical half, the basal carina is vestigial, and the tooth described for *spinosa* is lacking. In *cilicincta* there is a median keel, but the other differences hold the same as for *bicarinata*.

TIPHIA TIBETANA Turner

Tiphia tibetana TURNER, Ann. Mag. Nat. Hist., ser. 8, vol. 2, 1908, p. 121.

In the British Museum there are single male and females specimens, both of which are labeled type. There are also three females and three males labeled cotypes and an additional eight females and one male, Cyangtse, 13,000 feet, which are presumably from the Yangtze River valley in Tibet.

The type female of this species runs to *asericae* in our key, but the tegula differs in being black, and there is no preapical band sunk in a deep, narrow groove. It is somewhat difficult to say where the male type would run to in the present key. It has a tooth on the fifth sternite, the mesepisternum is not conspicuously bipunctate at the center of the disk, and the apex of the radial cell does not exceed the second cubital cell. It does not belong to any species in the *koreana* group, since it lacks the deep, overlapped groove just before the apex of the first abdominal segment. It also lacks the coarse, apical, ciliate row of bristles on the intermediate tergites, which are characteristic of the *bicarinata* group. This combination of characters would eliminate all species in our key except *pullivora*, *agilis*, and *asericae*. Gahan writes that the species is not *agilis*, but just how it differs from *agilis* and the other two species is not known.

TIPHIA CONSUETA Smith

Tiphia consueta SMITH, Descriptions of New Species of Hymenoptera, 1879, p. 184.

The type, a female from Ceylon, was examined in the British Museum by Gahan. He says that it runs in our key to *matura*, but can be separated from that species. The wings are not nearly as dark. The front and vertex appear much less strongly shagreened on the interspaces. The pronotum is less densely punctate anteriorly, and the punctures are somewhat coarser.

TIPHIA KHASIANA Cameron

Tiphia khasiana CAMERON, Ann. Mag. Nat. Hist., ser. 7, vol. 10, 1902, p. 86.

Described from the female; type locality not given. In the British Museum there is a female from Assam determined by Cameron, but not labeled type, and another female from Assam, which Gahan thinks may not be of the same species. This species runs to couplet 21 in our key, and Gahan writes that it is very similar to both forms included there. He finds that the pygidium is exactly like that of *pigmentata*, and that it is not wrinkled apically as in *biseculata*, that the punctation of front, pronotum, and abdomen is like that of *biseculata*, but is more pronounced than that of *pigmentata*, and that the hind tibiae are darker than those of *biseculata*.

TIPHIA PUNCTIFRONS Cameron

Tiphia punctifrons CAMERON, Entomologist, vol. 42, 1909, p. 175.

The type is a male from Borneo. Gahan notes that it has an elongate tegula exactly like that of *longitegulata*, of which the type is a female, and of which he had only females before him at the time his comparison was made. This character sharply separates the species from all the others discussed in the foregoing part of this paper.

We have males with the same peculiar, elongate tegula, that were taken with the females of *longitegulata* and are without doubt correctly associated. *T. punctifrons* is almost certainly a distinct species, differing in having the mesepisternum conspicuously bipunctate over all its surface, with the primary punctures distinctly larger than the secondaries, and in having the first two pairs of legs to the coxae, and the hind tibiae and femora red.

TIPHIA OSWINI Turner

Tiphia oswini Turner, Spolia Zeylanica, vol. 7, pt. 27, 1911, p. 152.

Gahan examined the type, a female from Ceylon, in the British Museum. He found that in our key it runs best to *longitegulata*, but is much larger, and is not of that species. The tegula is black, hardly twice as long as wide, though distinctly longer than broad, extending for fully one-third its length beyond the scutellar groove. The first tergite is not as coarsely or strongly punctate; the second tergite is nearly impunctate, except for a transverse, preapical row of punctures and a few very scattered, suberased punctures on the disk. The depressed area of the scutum is much less densely punctate. The median carina of the propodeum is subobsolete, except the basal third; the areola is well defined. The flagellar joints are all somewhat longer than wide; the apical joint is about four times as long as wide.

TIPHIA FLAVIPENNIS Smith

Tiphia flavipennis Smith, Journ. Proc. Linn. Soc. London, Zool., vol. 2, 1858, p. 91.

Originally described from the female from Borneo. There are three females and two males under this name in the British Museum. The following information regarding them is from Gahan: One female and one male from the Smith collection, taken in Borneo, are identical with other specimens under the name *lyrata* in the British Museum. Waterston says that these are cotypes. One female, also from Borneo, and determined by Cameron as *flavipennis*, agrees with our *longitegulata*, except that it is a little larger and that the tegula is lighter red. One of the males and one of the females belong to still another species.

TIPHIA INCISA Cameron

Tiphia incisa Cameron, Mem. and Proc. Manchester Lit. and Phil. Soc., vol. 41, no. 4, 1896–97, p. 49.

Described from the male from "Mussouri." Gahan examined a series under this name in the British Museum, which he noted could be separated into two and possibly three species on the basis of the characters used in our keys.

TIPHIA INTRUDENS Smith

Tiphia intrudens Smith, Journ. Proc. Linn. Soc. London, Zool., vol. 7, 1864, p. 25.

Originally described from both sexes from "Mysol." Gahan notes that, according to the characters we have used, there are several species under this name in the British Museum.

EXPLANATION OF PLATES

Plate 1

Fig. 1. Posterior aspect of mesepisternum of *T. fossata*, female, showing preapical groove. *c*, coxa; *me*, mesepisternum; *p g*, preapical groove.

2. Hypopigium of *T. bicarinata*, female, showing medio-apical impunctate stripe.

3. Major calcarium of the hind tibia of *T. popilliavora*, female, illustrating the type which is widest near the middle.

4. Major calcarium of the hind tibia of *T. communis*, female, illustrating the type which is not wider at the middle than at the base.

5. Scutum of *T. bicarinata*, female, showing notauli continuous with the antero-medial groove. *a gr*, antero-medial groove; *n*, notauli.

6. Scutum of *T. vernalis*, female, showing notauli not continuous anteriorly with the antero-medial groove. *a gr*, antero-medial groove; *n*, notauli.

7. Section of wing of *T. bicarinata*, male, in which the cubital cell contains a well-defined cubital mark, *c m*.

8. Clypeus of the female, *T. communis*, illustrating the type in which the lateral margin (*l m*) is strongly convex.

Plate 2

Fig. 9. Three degrees of density of primary punctures. *a*, first-degree density, in which most of the punctures are separated from three or more adjacent punctures by interspaces equal to or less than their own width; *b*, second-degree density, in which the punctures are arranged in single rows and are separated by interspaces equal to or less than their own width from only two other punctures; *c*, third-degree density, in which every interspace exceeds the width of the punctures.

10. Propodeal areola of *T. fukiensis*, male.

11. Propodeal aerola of *T. bicarinata*, female, illustrating the type with "keystone" outline. *d p*, dorso-propodeum; *e*, enclosed area; *l c*, lateral carina; *m c*, medial carina; *p p*, posterior aspect of propodeum; *s*, scutellum.

12. Propodeal areola of *T. lyrata*, female.

13. Propodeal areola of *T. communis*, female, illustrating the type with hastate outline.

14. Propodeal areola of *T. inconspicua*, female, illustrating the type with rectangular outline.

15. First tergite of *T. communis*, female, illustrating the type with a deep preapical fold (*p f*) overlapped at the middle.

16. First tergite of *T. vernalis*, female, illustrating the type having no preapical fold.

PLATE 3

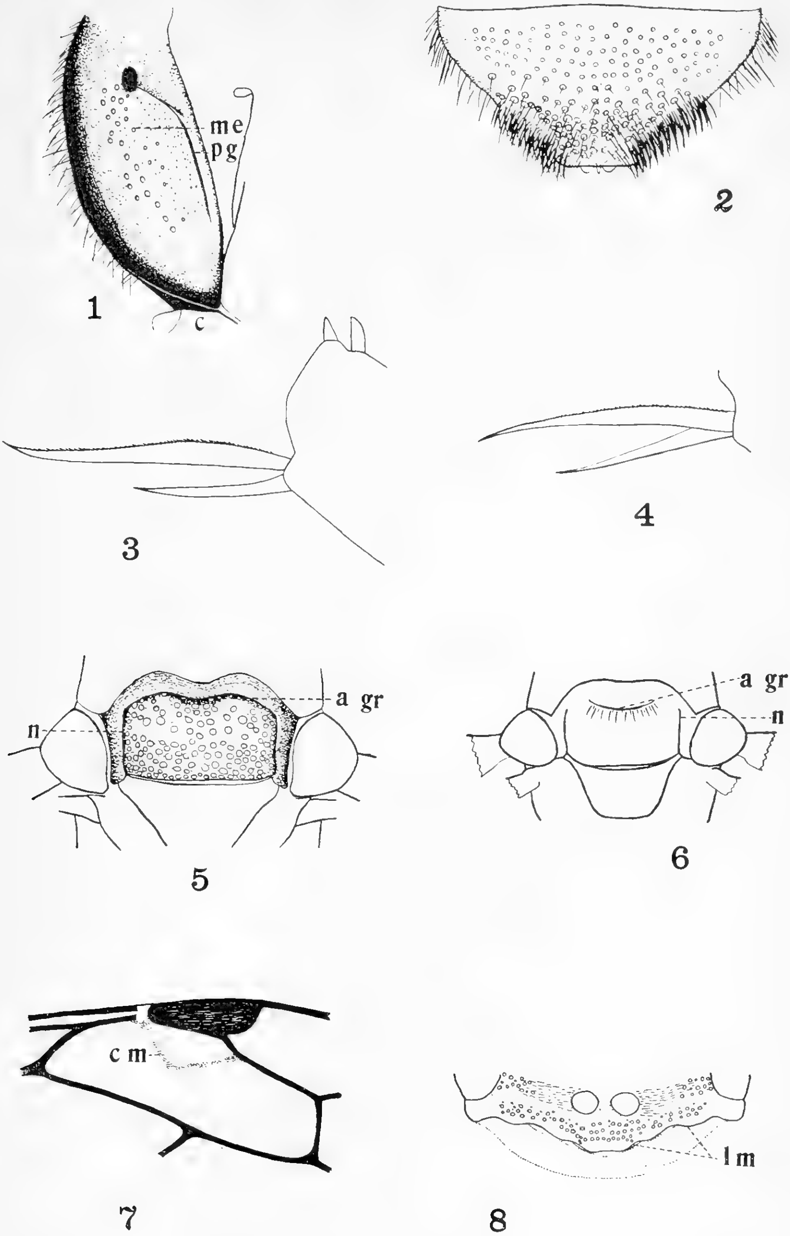
FIG. 17. Genitalia of *T. phyllophagae*, male. *aed*, aedeagus; *a h*, apical hook of the second genital segment; *a l*, apical lobe of the aedeagus; *i o*, inner clasper; *l p*, lateral process of apical portion of aedeagus; *o c*, outer clasper.

18. Genitalia of *T. communis*, male.
19. Genitalia of *T. vernalis*, male.
20. Genitalia of *T. rufomandibulata*, male.
21. Mandible of *T. popilliavora*, female, illustrating the type having median groove (*m g*).
22. Flexor surface of the hind basitarsus of *T. popilliavora*, female, illustrating the type having longitudinal groove and lanceolate spines with one spine of the same type at the apex.
23. Flexor surface of the hind basitarsus of *T. communis*, female, illustrating the type without longitudinal groove, with prickle-shaped spines, and without one of the same type of spines at the apex.
24. First segment of antenna of *T. bicarinata*, female, showing the pronounced angle at the apex.

PLATE 4

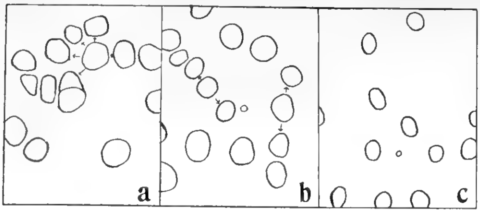
FIG. 25. Portion of wing of *T. vernalis*, male, illustrating the type in which the radial cell (*r*) exceeds the second cubital cell (*s cu*) in apical extension.

26. Portion of wing of *T. communis*, male, illustrating the type in which the radial cell (*r*) does not equal the second cubital (*s cu*) in its apical extension.
27. Portion of the fifth sternite of *T. popilliavora*, male, showing the lateral denticle (*d*).
28. Portion of vertex of *T. popilliavora*, female, showing the median series of minute punctures (*m p*).
29. Portion of the dorsal aspect of pronotum of *T. vernalis*, female, showing the vestigial median groove (*m g*) on the impunctate apex.
30. Portion of a tergite of *T. bisecculata*, female, showing the row of minute vestigial punctures (*v p*) caudad of the usual large, apical punctures.
31. Ventral aspect of first abdominal segment of *T. bisecculata*, female, showing the lateral grooves (*l g*) of the first sternite.
32. Pygidium of a female of the type which is punctate on not more than the basal three-fifths, and which has a well-defined impunctate emargination of the punctate portion. *i a*, impunctate apex; *i e*, impunctate emargination.



WASPS OF THE GENUS TIPHIA

FOR EXPLANATION OF PLATE SEE PAGE 103



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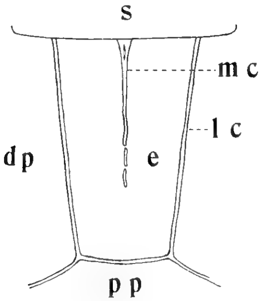

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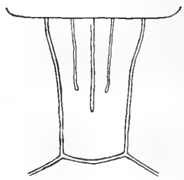

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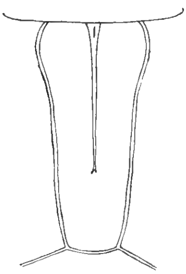

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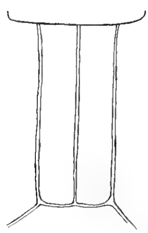

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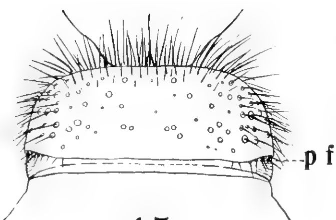

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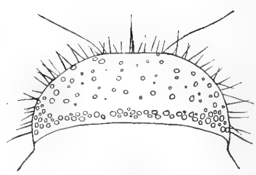

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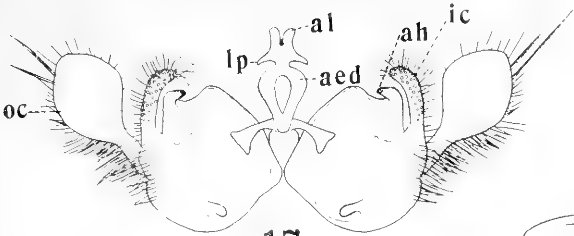
WASPS OF THE GENUS TIPHIA

FOR EXPLANATION OF PLATE SEE PAGE 103.



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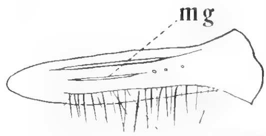

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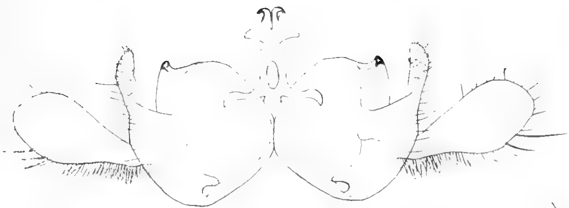

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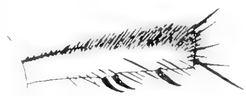

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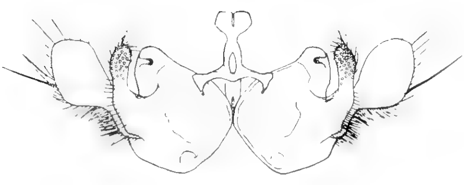

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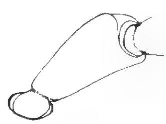

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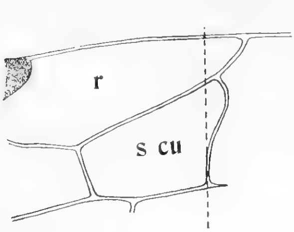
WASPS OF THE GENUS TIPHIA

FOR EXPLANATION OF PLATE SEE PAGE 104



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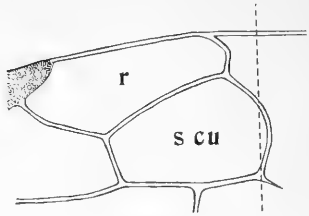

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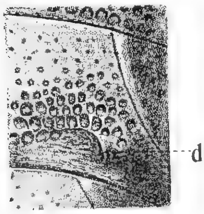

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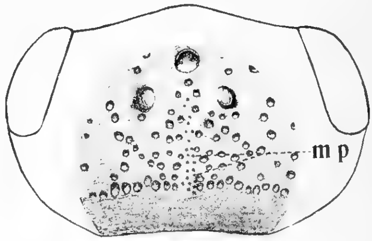

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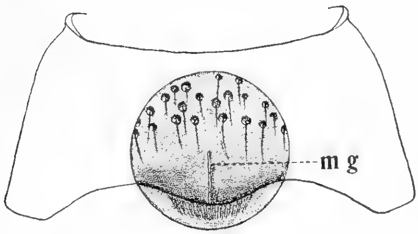

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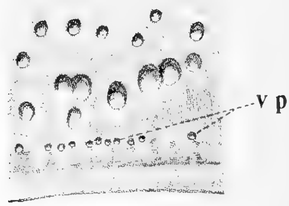

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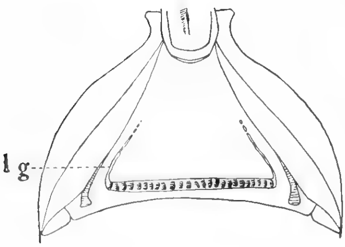

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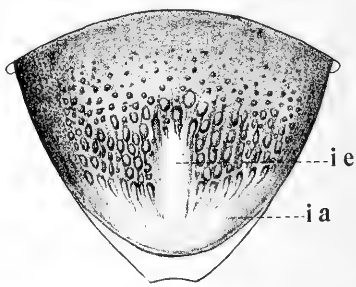

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WASPS OF THE GENUS TIPHIA

FOR EXPLANATION OF PLATE SEE PAGE 104.

INDEX

[In this index valid species names are given in italics; group names in Roman; most important page references in boldface]

U. S. GOVERNMENT PRINTING OFFICE: 1930

TWO NEW MOLLUSKS OF THE GENERA OSTREA AND EXOGYRA FROM THE AUSTIN CHALK, TEXAS

By Lloyd W. Stephenson
Of the United States Geological Survey

Two new species of Ostreidae recently found in the upper part of the Austin chalk of central Texas are of interest because of their restricted stratigraphic range, their known geographic range along linear distances respectively of 50 and 75 miles, and the great number of individuals representing each species. One of them, *Ostrea centerensis*, has been found at five localities along a line of outcrop 50 miles long, extending from Travis to Bell County, in a stratum a foot or less in thickness, which, on Little Walnut Creek in Travis County, lies about 25 feet below the top of the Austin chalk. The other species, *Exogyra tigrina*, occurs at its type locality on Little Walnut Creek in Travis County, in a stratum of chalky marl a foot or less in thickness, 35 feet below the top of the Austin chalk, 10 feet below the zone of *Ostrea centerensis*, and has been found at 5 other localities, two of them farther south in Travis County, and three toward the north, the most distant one being northeast of Temple in Bell County. The linear distance along which this species has been collected is 75 miles.

The species, *Exogyra tigrina*, is of especial interest because the original color markings of the shell are still well preserved. This, however, is not the first recorded species of this genus which exhibits color markings, for similar markings appear on an *Exogyra* from the upper Cenomanian and the lower Turonian of Europe, which Coquand[1] in 1869 figured under the name *Ostrea columba*, and described in the text under the name *Ostrea ratisbonensis*. He says: "La surface, dans les exemplaires bien conservés, est couverte de flammules brunes, obliques, en sautoir." The color markings on this species, as represented in Plate 45, Figures 8 and 9, of the paper cited, are very similar in character and distribution to those on *Exogyra tigrina*.

[1] Coquand, H., Monographie du Genre Ostrea, Terrain Crétacé, p. 121, pl. 45, figs. 8–12, 1869.

The section on Little Walnut Creek described below shows the stratigraphic position of each of the new species; the section was not accurately measured and the thicknesses given are only approximately correct.

Section on Little Walnut Creek in the vicinity of the iron bridge at the crossing of the old Sprinkle road, Travis County

	Feet
Taylor marl:	
Marly clay, poorly exposed	10
Unconformity?	
Austin chalk:	
Alternating layers of rather massive marly chalk and harder chalk; contains *Exogyra ponderosa* var. *erraticostata* Stephenson, and *Ostrea* species (aff. *O. diluviana* Linnaeus) within 10 feet of top	20
Rather soft argillaceous, marly chalk; a one-foot layer, 5 feet below the top contains many specimens of the new oyster, *Ostrea centerensis* Stephenson	15
Massive chalk with several softer marly layers; the upper one foot of chalk contains great numbers of the new oyster, *Exogyra tigrina* Stephenson, and just below this is a layer containing many shells of *Exogyra laeviuscula* Roemer (a varietal form); *Exogyra ponderosa* Roemer occurs in the lower part of the section	15

The type locality of *Ostrea centerensis* is a ravine north of the public road, 2¾ miles west-northwest of Sparks, ⅝ mile north of Center Lake School, Bell County. In this ravine marly chalk, exposed downstream for about 100 yards, contains considerable numbers of this new oyster; the marly bed ends against a small fault whose downthrow is toward the road, and a chalk bed exposed on the north or upthrow side of the fault contains the shells of *Exogyra tigrina* Stephenson. Doubtless the latter bed belongs stratigraphically below the former, as it does in the section on Walnut Creek.

The photographs (pls. 1–3) were made by W. O. Hazard, in the photographic laboratory of the United States Geological Survey, and were retouched by Frances Wieser, also of the Geological Survey.

OSTREA CENTERENSIS, new species

Plates 1 and 2

Description.—Shell of medium size, inequivalve, subovate somewhat elongate in outline, generally curving more or less strongly backward, though nearly straight in some individuals; valves flattish, close-fitting with little room for the soft parts when tightly closed; shell wall thin to moderately thick, but tough and strong; the shell shows a tendency to the development of wing-like anterior and posterior projections in the dorsal portion, but this is a variable feature. Dimensions of the type, a nearly complete individual with both valves preserved: Length 70 mm., height 68 mm., thickness 12 mm. Dimensions of a large left valve (pl. 2, figs. 1, 2): Length 83 mm., height 85 mm., convexity 10 mm.

Beaks relatively small, projecting slightly above the hinge, generally curved over to the left from the plane of contact of the two valves.

Left valve flattish to slightly convex, smooth, with the exception of fine growth lines, some stronger growth lamellae, and irregularities due to crowding; scar of attachment relatively small, the oyster showing a decided preference for attachment to the shells of an elongated mollusk, probably *Gervilliopsis;* margins overlapping the margins of the right valve.

Right valve smaller, flatter, and smoother than the left valve, and wing projections less pronounced.

Hinge triangular, the base a little longer than the sides; ligamental groove more deeply impressed on the left than on the right valve; adductor scars of moderate size, situated high, and toward the posterior margin of the shell; a small pedal muscle scar is just below the lower end of the ligamental groove; on some specimens irregular striations appear on the inner surface where the upper ends of the posterior and anterior margins of the right valve fit against the left valve just below the hinge.

Remarks.—This species is unique among the many oysters in the Cretaceous deposits of the Atlantic and Gulf Coastal Plain. Though simple, plain, and of moderate size, it presents characters which unmistakably distinguish it from all other species. It has been found only in one zone a foot or two in thickness, along a linear distance of nearly 50 miles. It appears to have no ancestors in the older Cretaceous deposits of the Coastal Plain and, so far as known, it left no descendants. It appeared suddenly in an environment that was evidently favorable, for the individual shells are numerous. It remained only for a moment (in a geologic sense), and for some unknown reason disappeared as suddenly as it had come. The most probable fatherland for the immigrant stranger is perhaps the tropical seas of the Caribbean region, the Cretaceous history of which is imperfectly known. If this be true, the cause of the appearance and disappearance of the species might be surmised to have been a temporary warming up of the waters of the Gulf region, followed by a cooling off of the waters to a degree unfavorable to the survival of the young oysters.

Types.—Holotype: Cat. No. 73657, U.S.N.M., from a ravine 2¾ miles west-northwest of Sparks, Bell County. (See below.)

Paratypes: Cat. No. 73658, U.S.N.M., from Cottonwood Creek, 2.7 miles north-northwest of Hutto, Williamson County; Cat. No. 73659, U.S.N.M., from Little Walnut Creek, 2¼ miles southwest of Sprinkle, Travis County. (See below.)

Distribution.—Upper part of Austin chalk: On the downthrow side of a small fault, in a ravine 2¾ miles west-northwest of Sparks,

5/8 mile north of Center Lake School, Bell County (U. S. G. S. Coll. 14074); Cottonwood Creek, 2.7 miles north-northwest of Hutto, 2 miles west-southwest of Montadale, Williamson County (U. S. G. S. Coll. No. 14072); near top of hill west of F. V. Browning's ranch house, 3.1 miles south by east of Hutto, Williamson County (U. S. G. S. Coll. 14071); 25 feet below top of Austin chalk, on Little Walnut Creek, 2¼ miles southwest of Sprinkle, 0.2 mile downstream from the iron bridge of the old Sprinkle road crossing, Travis County (U. S. G. S. Coll. No. 14163).

In addition to the localities just enumerated, where collections were made, this oyster was observed in a branch east of the public road, 1.5 miles south of Jonah, Williamson County.

EXOGYRA TIGRINA, new species

Plate 3

Description.—Shell small for the genus, inequivalve, broadly subovate in outline; shell wall of moderate thickness. Dimensions of the holotype: Length 56 mm., height 53 mm., thickness 31 mm.

Left or lower valve much larger than the right, strongly convex, attached at the tip of the beak where only a very small scar of attachment is present on most specimens. The valve is rather openly spiral, attaining about 2½ volutions in the holotype. Umbonal ridge pronounced, round-crested, sloping steeply on either side, curved to conform to the spiral twist of the shell. Hinge narrow and curved in the manner normal to the genus; ligamental groove narrow, deeply impressed. Adductor scar of medium size, situated a little above the midheight and toward the rear.

Surface of left valve smooth for several millimeters back from the beak, beyond which it is ornamented with irregular, round-crested costae of weak to moderate strength; these bifurcate frequently on the umbonal ridge, and less frequently on the slopes; about the outer half of the surface of the larger individuals is modified by the more or less prominent development of concentric, imbricating growth lamellae which at their intersections with the costae expand outward in spinelike folds 1 or 2 millimeters high; these folds vary in prominence and are easily broken, none of them being perfectly preserved. The surface is further marked by brownish, radiating color bands, which alternate with gray bands; their distribution is similar to that of the costae on the posterior slopes of which they are chiefly developed; however, they sometimes occupy the interspaces or the crests of the costae; their distribution was apparently controlled by the costae. This is one of the rare cases

in which the color markings of the living shell are preserved in the fossil state. These color markings are present on most of the specimens collected from the six localities, their apparent absence on some individuals being due to weathering and leaching.

Upper or right valve flatly spiral, operculiform, slightly convex anteriorly, becoming concave posteriorly, fitting neatly within the margins of the left valve. Surface ornamented with numerous sharp-edged lamellae, separated by deep depressions, which are closely spaced on the anterior part of the shell, and more widely spaced posteriorly; on the type there is also an insipient development of irregular costae which produce the same sort of spinelike folds where they cross the concentric lamellae, as are present on the left valve, but costae are absent on some specimens; color bands are wanting on the right valve. Ligamental groove narrow and deeply impressed.

Remarks.—This species is about the same size and has about the same general form as *Exogyra laeviuscula* Roemer, an upper Austin chalk species. Roemer's species is smooth, with no indication whatever of radiating costae, and is entirely wanting in color bands; it is also broader in the umbonal region, has a less prominent and more rounded umbonal ridge, and is not quite so openly coiled.

Like most other oysters this species varies considerably in outline and form and in the coarseness of the costae. In some individuals the costae are considerably finer than they are in the type.

So far as known the species is confined to a zone only a foot or two in thickness. It was first collected in 1894 by Dr. Robert T. Hill at the two localities (see below) which are south of Colorado River, in Travis County.

Type.—Cat. No. 73660, U.S.N.M. From Little Walnut Creek, 2¼ miles southwest of Sprinkle, Travis County. (See below.)

Distribution.—Upper part of Austin chalk: Onion Creek, half a mile above Bluff Springs, Travis County (Hill Coll. No. 54, U.S.N.M.); Williamson Creek between the upper and lower Lockhart road crossings, Travis County (Hill Coll. No. 51, U.S.N.M.); Little Walnut Creek, 0.2 mile downstream from the iron bridge of the old Sprinkle road crossing, 35 feet below top of Austin chalk, 2¼ miles southwest of Sprinkle, Travis County (U. S. G. S. Coll. 14164); public road, 1.2 miles south of Jonah, Williamson County (U. S. G. S. Coll. 13809); on the upthrow side of a small fault, in ravine 2¾ miles west-northwest of Sparks, ⅝ mile north of Center Lake School, Bell County (U. S. G. S. Coll. 14073); Little Elm Creek, 2.4 miles northeast of Temple, Bell County (U. S. G. S. Coll. 13822).

EXPLANATION OF PLATES

[All figures natural size]

Plate 1

Ostrea centerensis Stephenson (p. 2)

Figure 1. Exterior of the left valve of the type. Cat. No. 73657, U.S.N.M.
2. Exterior of the right valve of the type, showing also overlapping margins of the left valve.
3. Interior of a right valve from Cottonwood Creek, 2.7 miles north-northwest of Hutto, Williamson County. Cat. No. 73658, U.S.N.M.

Plate 2

Ostrea centerensis Stephenson (p. 2)

Figure 1. Exterior of a large left valve from Little Walnut Creek, 2¼ miles southwest of Sprinkle, Travis County, showing its scar of attachment to an elongated pelecypod shell. Cat. No. 73659, U.S.N.M.
2. Interior of the same left valve.
3. Front edge view of the type (Cat. No. 73657 U.S.N.M.), showing the thickness of the shell with the two valves tightly closed.

Plate 3

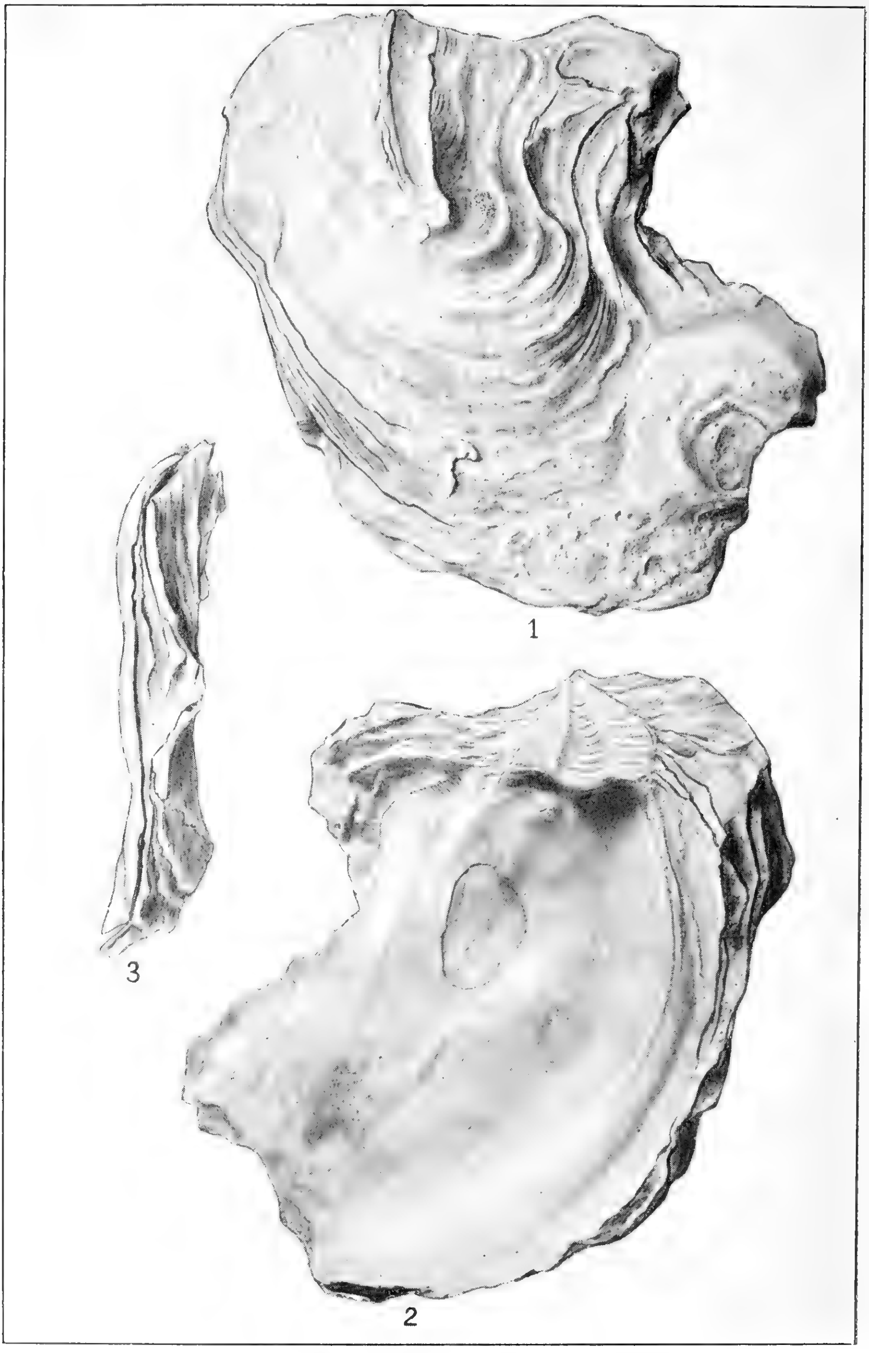
Exogyra tigrina Stephenson (p. 4)

Figure 1. Exterior of the left valve of the type, showing the original color markings. Cat. No. 73660, U.S.N.M.
2. The same, photographed after coating with ammonia chloride to cover up color markings, and bring out the true sculpture.
3. Edge view of the same showing thickness and color markings.
4. Interior of the same.
5. Exterior of the right valve of the type, showing the overlapping margins of the left valve.
6. Interior of the right valve of the type.

U. S. GOVERNMENT PRINTING OFFICE: 1929

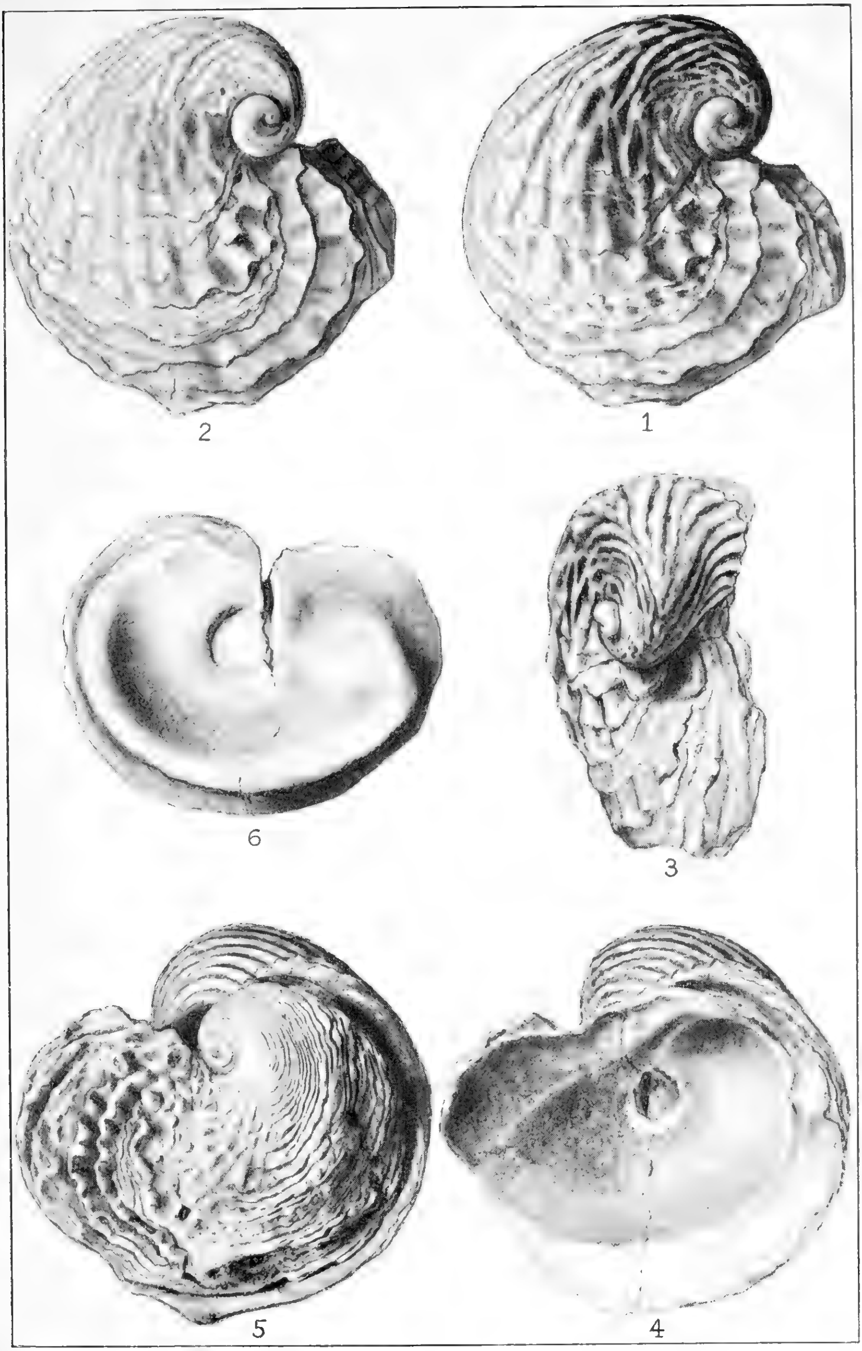
A NEW SPECIES OF FOSSIL OYSTER FROM TEXAS

FOR EXPLANATION OF PLATE SEE PAGE 6



A NEW SPECIES OF FOSSIL OYSTER FROM TEXAS

FOR EXPLANATION OF PLATE SEE PAGE 6



A NEW SPECIES OF EXOGYRA WITH COLOR MARKINGS PRESERVED

FOR EXPLANATION OF PLATE SEE PAGE 6

THE FORAMINIFERA OF THE RIPLEY FORMATION ON COON CREEK, TENNESSEE

By Willard Berry and Louis Kelley

Of the Johns Hopkins University

This paper presents the results of a systematic study of the Foraminifera found in the Upper Cretaceous exposed on Coon Creek in McNairy County, Tenn. The material is from the Coon Creek tongue of the Ripley formation which is stratigraphically at the base of the Ripley formation and in the *Exogyra costata* zone.

The locality from which this material was collected is known as Dave Weeks' place on Coon Creek. It is in the northeastern part of McNairy County, 3½ miles south of Enville, 7½ miles north of Adamsville, and one-eighth of a mile east of the main Henderson-Adamsville road.

The sediments here are in general very like those of the Upper Cretaceous exposed at Brightseat, Md. The matrix was examined petrographically and the following minerals were found after the carbonates had been removed: Light minerals about 97–98 per cent made up of about half subangular grains of quartz and about the same amount of glauconite. The heavy minerals constituted only 2–3 per cent of the material and they were in order of their frequency, pyrite, blue kyanite, rounded staurolite, muscovite, sillimanite, brown hornblende, epidote, alkali and iron varieties of tourmaline, garnet, rutile, and monazite or zircon (?). All these minerals except the pyrite show well-rounded outlines.

The Foraminifera are extremely well preserved, much better preserved in fact than any other Upper Cretaceous Foraminifera found in this country with the possible exception of those at Brightseat, Md. In general the fossils look at first glance like late Tertiary and not Upper Cretaceous material.

The Foraminifera described from this material comprise 19 genera with a total of 37 species and varieties. Of these 37 species and varieties 19 are new to science. The lack of micropaleontologic work in the area and the extremely good condition of preservation would account for this large proportion of new species and varieties.

All the genera and species here found are, with the exception of the plagic forms, all inhabitants of fairly shallow waters. This, coupled with the abundance of glauconite, would indicate shallow seas, as does the associated molluscan fauna. The fauna as a whole has strong Cretaceous affinities but so many species are new that close comparisons are not possible. When some other well preserved Cretaceous foraminiferal deposits are found we will be better able to compare this fauna with them.

A very complete account of the larger fauna and the geology of the area is to be found in the very excellent work of Bruce Wade, published as Professional Paper 137 of the United States Geological Survey, (1926), entitled "The Fauna of the Ripley Formation on Coon Creek, Tenn." In this paper Wade goes into detail concerning the geologic relations of the fauna and also the ecologic conditions.

In this present work the senior author has described all but two of the species and has discussed the entire fauna. The junior author started the work, but economic conditions took him into the field before he had time to more than get started, and the senior author took over the material and followed it to a conclusion.

The types of this material are the property of the United States National Museum.

Family LITUOLIDAE

Genus REOPHAX Montfort, 1808

REOPHAX CYLINDRICUS H. B. Brady, var. RIPLEYENSIS W. Berry, new variety

Plate 1, Figure 5

Test elongate, slightly tapering, straight, ratio of length to diameter about 5:1, free. Chambers distinct, round, tumid in the middle, about as long as broad, serial, closely attached. Sutures slightly depressed; wall thin, composed of many sharp sand grains and little cement. Aperture a ragged hole in the end of the last chamber.

Length, 1.28 mm.

This variety is not closely related to the parent species, as shown by the less regular structure. It is related as shown by its general appearance and characteristics. It is the largest *Reophax* found in the Ripley at this outcrop.

Holotype.—Cat. No. 73661, U.S.N.M.

REOPHAX COONENSIS W. Berry, new species

Plate 3, Figure 23

Test small, cylindrical, straight, short, ratio of length to diameter about 3:1, free. Chambers indistinct, usually 3 to 4 in number, tumid in the middle. Sutures slightly depressed, usually very indis-

tinct. Walls stout, arenaceous, with much cement. Aperture a simple hole at the end of the last chamber; there is no evidence of a neck, as in most species of this genus.

Length, 0.59 mm.

This species of *Reophax* looks very like certain species of *Hormosina*, but in thin section it is at once evident that it belongs to the genus *Reophax*. It does not seem to be closely related to any of the described species of the genus. If it should prove to be unique for this part of Ripley it should be of much economic importance.

Holotype.—Cat. No. 73662, U.S.N.M.

Family TEXTULARIIDAE

Genus TEXTULARIA Defrance, 1824

TEXTULARIA AGGLUTINANS d'Orbigny

Plate 2, Figure 1

Textularia agglutinans D'ORBIGNY, Foram, Cuba, 1839, p. 144, pl. 1, figs. 17–18 and 32–34.—H. B. BRADY, Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 363, pl. 63, figs. 1–3.—CUSHMAN, Foram. Atlantic Ocean, U. S. Nat. Mus. Bull. 104, pt. 3, 1922, p. 7, pl. 1, figs. 4–5.

Test elongate, tapering, small, ratio of length to width about 3:1. Chambers slightly inflate giving a rough outline, biserial throughout. Chambers numerous usually about 9 in an adult specimen, have usual Textularian shape with rounder exterior margins. Sutures slightly depressed, fairly distinct; wall arenaceous, fair amount of cement. Aperture simple arched slit on the interior face near point of attachment of last chamber.

Length, 0.86 mm.

This species, which has been described from the Cretaceous of New Jersey,[1] and the Midway of Texas[2] is the most common *Textularia* found in the Ripley on Coon Creek. The specimens fit into the species closely.

Plesiotype.—Cat. No. 73663, U.S.N.M.

TEXTULARIA SAGITTULA Defrance, var. COONENSIS W. Berry, new variety

Plate 2, Figure 3

Test elongate, tapering, small, ratio of length to width about 2:1. Chambers extremely small, numerous, usually about 20 in an adult specimen; chambers form a sharp angle at the margin and are arranged biserially. Sutures distinct, even with the surface, slightly limbate, wall thin hayaline, perforate, colorless. Aperturial end usually not preserved. Where it is present the aperture is a simple arched slit at the line of attachment of the last formed chamber.

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[1] Bagg, Bull. 88, U. S. Geol. Surv. [2] Plummer, Univ. Texas Bull. 2644.

This variety differs from the parent species in having a more hyaline test. It is of small size and in this material it is poorly preserved. The thin walls do not stand handling, and they are also apparently partly dissolved by the water circulating through the formation. It is a rather pretty variety and shows the arrowlike form of the parent species.

Holotype.—Cat. No. 73664, U.S.N.M.

TEXTULARIA RIPLEYENSIS W. Berry, new species

Plate 2, Figure 2

Test elongate, tapering, small, ratio of length to width about 1.3 : 1. Chambers, usually 10 in number in adult specimens, inflate, causing them to rise well above the area of the sutures, have a salient angle on the margin, and are arranged biserially. Sutures distinct, depressed, causing chambers to be extremely well emphasized. Wall arenaceous, with much cement. Aperture a simple arched slit extending entirely across the interior face near the line of attachment of the final chamber.

Length, 0.55 mm.

This species is related to *T. carinata* d'Orbigny, *T. milletti* Cushman, and *T. mexicana* Cushman. Sandridge has described a similar species in manuscript from the Ripley of Alabama, but, as I have not been able to see either the specimens or the figures, I can not say definitely that it is the same as this species from the Ripley of Coon Creek. *T. ripleyensis* is fairly common in this material and should be easily identified.

Holotype.—Cat. No. 73665, U.S.N.M.

Genus BOLIVINA d'Orbigny, 1839

BOLIVINA PLAITA Carsey

Plate 1, Figure 14

Bolivina plaita Carsey, Univ. Texas Bull. 2612, 1926, p. 26, pl. 4, fig. 2.
Proroporus plaita (Carsey) Cushman, Contrib. Cush. Lab. Foram. Research, vol. 2, pt. 4, 1927, p. 89, pl. 12, figs. 7*a–b*.

Test elongate, subcylindrical, very slightly compressed, apical end rounded with a flat portion for the extreme end; chambers numerous, usually about 15 in an adult specimen, high, very slightly inflate, arranged in an alternating biserial series; sutures nearly flush, very slightly limbate, curving slightly in the direction of the older chambers; wall hyaline, finely punctate, otherwise smooth except for the limbate sutures; aperture loop-shaped, elongate; color transparent to translucent white.

Length, 0.94 mm.

This species is the only *Bolivina* found in the material from Coon Creek. It is rather common and characteristic. Cushman says [3] it is very close to *B. reussi* Geintz. I can find little similarity. *B. plaita* is found in the Navarro of Texas and in the Ripley at Owl Creek, Miss., as well as in the Ripley of Coon Creek.

Plesiotype.—Cat. No. 73666, U.S.N.M.

Genus BULIMINA d'Orbigny, 1826

BULIMINA QUADRATA Plummer

Plate 2, Figure 7

Bulimina quadrata PLUMMER, Univ. Texas Bull. 2644, 1926, p. 72, pl. 4, figs. 4–5

Test elongate, stout, cylindrical, slightly tapering, aboral end bluntly rounded; chambers smooth, slightly inflated, arranged in a slight Textularian series, usually 8–9 chambers in the adult test; sutures sharp, only slightly depressed; aperture a large vertical slit on the inner side of the last chamber.

Length, 0.44 mm.

This specimen agrees very closely with that figured as the megalospheric form of the species by Mrs. Plummer. She records it from the upper faunule of the Midway formation of Texas.

Plesiotype.—Cat. No. 73667, U.S.N.M.

Family LAGENIDAE

Genus LAGENA Walker and Boys, 1784

LAGENA SULCATA (Walker and Jacob) var. SEMIINTERUPTA W. Berry, new variety

Plate 3, Figure 19

Test flask-shaped, body portion subglobular, ornamented with numerous fine, platelike costae; these costae are even in number and are arranged in loops starting at the base of the apertural neck, going almost to the apical end, and returning to the starting place but not connecting; the pairs alternate in their distance from the apical end; neck smooth, ending in a simple circular aperture.

Length, 0.48 mm.

This variety is in general like the parent species but differs greatly in the costae. In this variety they are formed in pairs, that is, they run from the apertural end to the apical end, but before reaching it they loop back. The pairs also alternate in their approach to the apical end. It is a very rare and delicate variety.

Holotype.—Cat. No. 73668, U.S.N.M.

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[3] Contr. Cush. Lab. Foram. Research, vol. 2, pt. 4, 1927, p. 89.

Genus DENTALINA d'Orbigny, 1826

DENTALINA COMMUNIS d'Orbigny

Plate 2, Figure 10

Nodosaria (*Dentalina*) *communis* D'ORBIGNY, Ann Sci. Nat., vol. 7, 1826, p. 254, No. 35.

Dentalina communis D'ORBIGNY, Mem. Soc. Geol. France, vol. 4, 1840, p. 13, pl. 1, fig. 4.—H. B. BRADY, Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 504, pl. 62, figs. 19–22.—CUSHMAN, Foram. Philippine and Adj. Seas, U. S. Nat. Mus. Bull. 100, 1921, pp. 192–193, pl. 34, fig. 7.

Test elongate, moderately slender, tapering very slightly, compressed, rounded at the apical end; early chambers broader than long, increasing gradually in length until the final chambers are about one-third longer than broad, numerous, usually 8–9; surface smooth, polished; aperture eccentric on a slight protuberance.

Length, 0.55 mm.

This is the only *Dentalina* found in this material. It is easily recognized, and as far as I know has not been found in the Cretaceous of the United States except by Bagg [4] in the Mommouth and Rancocas formations of New Jersey.

Plesiotype.—Cat. No. 73669, U.S.N.M.

Genus NODOSARIA Lamarck, 1812

NODOSARIA AFFINIS d'Orbigny

Plate 1, Figure 8

Nodosaria affinis D'ORBIGNY, Foram. Foss. Vienne, 1846, p. 39, pl. 1, figs. 36–39.—PLUMMER, Univ. Texas Bull. 2644, 1926, p. 89, pl. 14, figs. 2*a–d*.

Test elongate, tapering, composed of numerous subcylindrical, oval chambers fairly closely connected; walls ornamented with heavy longitudinal costae running the entire length of the test, sutures depressed but filled with clear material over which the costae run; apical end usually terminated with a spine, aperture on the extreme end of a short neck.

Length, greater than 1.80 mm.

Nodosaria affinis is rather common in the Ripley of Coon Creek. It is easy to see, due to its large size and its usual white color. It has been described from the Midway of Texas, and under other names similar forms have been described from the Lias to the recent. In this material it shows constant characters which would tend to show that there is every reason to call it a fixed species at least in this area.

Plesiotype.—Cat. No. 73670, U.S.N.M.

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[4] Bull. 88, U. S. Geol. Survey, p. 37.

NODOSARIA PROXIMA Silvestri

Plate 1, Figure 13

Nodosaria proxima SILVESTRI, Atti Accad. Gioenia, Catania, ser. 3, vol. 7, 1872, p. 63, pl. 6, figs. 138–147.—H. B. BRADY, Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 511, pl. 64, fig. 15.—CUSHMAN, Foram. N. Pacific Ocean, U. S. Nat. Mus. Bull. 71, pt. 3, 1913, p. 52.

Test elongate, slender, composed of several spherical chambers connected by short necks or tubes; surface ornamented with longitudinal costae extending the entire length of the test; aperture on the end of the last formed neck.

Length, 0.68 mm.

This small species was first described by Silvestri from the Subpennine Clay of San Quirico near Sienna. These clays are generally thought to be of Pliocene age, but it is now known that there are clays in the Appennines of Cretaceous age. These Cretaceous clays contain plants of Senonian age and also carry cycad stumps. It is entirely possible that the clays from which Silvestri described *N. proxima* were of Cretaceous age.

This species is rare in the Ripley at Coon Creek, but as it is the only 2-chambered species it is easily identified from any of the other species.

Plesiotype.—Cat. No. 73671, U.S.N.M.

NODOSARIA, species

Plate 1, Figure 9

Test composed of slightly inflated chambers with smooth walls. These chambers are so broken as to give no clue to the conditions of the rest of the test.

This small fragment of *Nodosaria* is of no value in determining what its affinities might be. It is of interest to note it with the hope that future work will bring to light more complete specimens and so lead us to the determination of its true species.

Genus CRISTELLARIA Lamarck, 1812

CRISTELLARIA MIDWAYENSIS Plummer

Plate 1, Figure 3

Cristellaria midwayensis PLUMMER, Univ. Texas Bull. 2644, 1926, p. 95, pl. 13, fig. 5*a–c*, 1926.

Test large, closely coiled, biconvex; peripheral margin carinate; composed of numerous chambers usually 11–12 in the last formed whorl of adult specimens, 9–10 in younger specimens; sutures distinct, slightly limbate and raised near the umbo; aperture radial.

Diameter, greater than 1 mm.

This is the largest and most common species of *Cristellaria* in the material from Coon Creek. Mrs. Plummer reports it as a common form in the Midway of Texas.

Plesiotype.—Cat. No. 73673, U.S.N.M.

CRISTELLARIA ORBICULARIS (d'Orbigny), var. MINUTA W. Berry, new variety

Plate 1, Figure 2

Test closely coiled, biconvex, composed of numerous chambers, usually 7–8 in the last formed coil; peripheral margin acute to subcarinate; sutures slightly limbate and slightly raised; there is a slightly raised umbo; walls smooth, shiny; aperture radial and visible in several chambers before the final one.

Diameter, 0.74 mm.

This variety, which bears a close resemblance to the species *C. orbicularis*, is smaller and does not have such a distinct keel. It is fairly common in the material from Coon Creek.

Holotype.—Cat. No. 73674, U.S.N.M.

CRISTELLARIA WADEI W. Berry, new species

Plate 1, Figure 1

Test small, closely coiled, biconvex; chambers numerous, usually about 8 in the last formed coil; peripheral margin very acute, carniate with a thin keel about one-eighth of the length of the rest of the test; sutures very slighly depressed; surface smooth; aperture radial.

Length, 0.64 mm.

C. wadei is somewhat like *C. submamillegera* Cushman in general appearance of the keel, but does not have the raised ridge extending to the umbo, and is smaller. *C. wadei* can be compared with *C. expansa* Cushman but, again it is smaller and lacks the alar projection. Complete specimens of this species are rare in the material; in most cases the thin keel is broken off either entirely or in parts, both of which conditions are apt to lead one to incorrect conclusions.

Holotype.—Cat. No. 73675, U.S.N.M.

Genus VAGINULINA d'Orbigny, 1826

VAGINULINA WADEI Kelley, new species

Plate 1, Figure 7

Test elongate, slender, compressed except proloculum, broadening slightly with the addition of chambers; periferal edge straight, proximal edge nearly so; apertural face at an angle of about 45° with periferal edge; chambers 8 in number, proloculum spherical, subsequent chambers elongate oblique, slanting down from the periferal edge to the proximal edge at an angle of about 45°, ornamented with 14 longitudinal costae on the proloculum, 16 on the third and

fourth chambers and becoming fainter on the younger parts of the test, the most pronounced being three each on the periferal and proximal edges which continue unabated in relief throughout the test; sutures slightly depressed, nearly straight; wall hyaline, highly transparent condition of the test shows the intercameral walls to be broad, thick; aperture radiate, round, terminal on a slight projection at the junction of the apertural face and periferal edge.

Length, 1.38 mm.

This species is somewhat like one found by Sandige, (MS.), in the Ripley of Alabama, but has a greater number of chambers and is more transparent. It is very rare in the Coon Creek material, but when present is very noticeable and easily identified.

Holotype.—Cat. No. 73676, U.S.N.M.

Genus FRONDICULARIA Defrance, 1824

FRONDICULARIA ANGUSTISSIMA Reuss

Plate 1, Figure 10

Frondicularia angustissima RUESS, Marsson, Die Foraminifera der Schreibkeide de Insel Rügen 1877.—EGGER, Abh. d. II, Cl. d. k. Akad. d. Wiss., XXI, vol. 1, Abth. 1902.

Test elongate, evenly compressed, slightly wider near the apertural end, rectangular in traverse section; chambers few 6–7 in number, bearing a blunt apical spine and 4 or 5 distinct longitudinal costae, later chambers chevron-shaped, last one drawn out to a neck bearing a ball-shaped aperture; sutures distinct, raised, forming inverted V's; wall smooth, transparent, glossy; aperture terminal at the end of the neck on the small sphere, produced, round, radiate.

Length, 1.05 mm.

This species, which is extremely rare in the Coon Creek material, is only reported from the Cretaceous. It should prove a good horizon marker if it is present in large enough numbers to be readily found. It is the only occurrence of the species in the Cretaceous of the United States, so far as I know.

Plesiotype.—Cat. No. 73677, U.S.N.M.

Genus POLYMORPHINA d'Orbigny, 1826

POLYMORPHINA LACTEA (Walker and Jacob)

Plate 1, Figure 12

Serpula lactea WALKER and JACOB (according to Kaumacher), 1794, Adam's Essays, ed. 2, p. 634, pl. 14, fig. 4.

Polymorphina lactea MACGILLIVRAY 1843, Moll. Aberdeen, p. 320.—H. B. BRADY, Rept. Voy. *Challenger*, Zoology, vol. 9, p. 559, pl. 71, figs. 11, 14.

Test small, rounded to ovate, front view circular; chambers elongate, few, usually 3–4; sutures distinct even, slightly limbate; wall smooth; aperture terminal, radial, slightly elevated.

Length, 0.56 mm.

This small almost spherical species is cosmopolital and ranges from the Jurassic [5] to the recent seas. It has not been met with before in the Ripley.

Plesiotype.—Cat. No. 73678, U.S.N.M.

POLYMORPHINA GUTTA d'Orbigny

Plate 1, Figure 11

Pyrulina gutta D'ORBIGNY, 1826, Ann. Sci., vol. 7, p. 267, No. 28, pl. 12, figs. 5–6.
Polymorphia, (Pyrulina), gutta, PARKER and JONES, 1863, Ann. Mag. Nat. Hist., ser. 3, vol. 12, p. 440, No. 21.—FRANKE, 1925, Foram. pommerschen Kreide, Abh. geol.-paleon. Inst. U. Griefswald, vol. 6, p. 77, pl. 6, figs. 16*a*—*b*.

Test elongate, more or less rounded, cylindrical initial end rounded, apertural end obtusely pointed, chambers fairly numerous, 4–5 in adult specimens, smooth, elongate, sutures distinct level, last formed chamber bearing a well-developed entirely radiate aperture, wall smooth, translucent.

Length, 0.80 mm.

This form, which is rather common in this material, is a very beautiful one. It has not been found before in the Cretaceous of the United States, so far as I know.

Plesiotype.—Cat. No. 73679, U.S.N.M.

POLYMORPHINA AMPLA Karrer

Plate 1, Figure 4

Polymorphina ampla KARRER, 1870, Über ein neues Vorkommen von oberer Kreide in Leitzerdorf bei Stockerau und der Foraminifera-Fauna.—EGGER, 1902, Abh. d. II. Cl. d. k. Akad. d. Wiss. XXI, vol 1. Abth., p. 126. pl. 17, fig. 32.

Test fairly large, rounded elongate, decidedly compressed; chambers few usually about 5–7; obliquely placed; sutured distinct, level, slightly limbate; wall thin, perforate, smooth; aperture terminal, radiate.

Length, 1.56 mm.

This is the largest *Polymorphina* found in this material. Its large size and flattened condition readily set it off from any others occurring in the formation. It has not before been recorded from the American Cretaceous.

Plesiotype.—Cat. No. 73680, U.S.N.M.

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[5] Moore, Quart. Jour. Geol. Soc., vol. 27, pp. 236, 239.

Family GLOBIGERINIDAE

Genus GLOBIGERINA d'Orbigny, 1826

GLOBIGERINA CRETACEA d'Orbigny

Plate 3, Figures 7, 8, 9

Globigerina cretacea D'ORBIGNY, Mem. Soc. Geol. France, ser. 1, vol. 4, 1840, p. 34, pl. 3, figs. 12–14.—H. B. BRADY, Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 596, pl. 82, figs. 10*a–c* (?).—CUSHMAN, J. A., Foram. of the Philippine and Adjacent Seas, U. S. Nat. Mus. Bull. 100, 1921, p. 287.

Test composed of numerous inflated chambers arranged in a slightly trochoid nautiloid spiral, chambers all visible from above, very umbilicate below with only the chambers of the last formed whorl visible, chambers usually 5–6 in number in the last whorl; wall thin, reticulate with slight traces of spine bases; apertures of chambers open into the umbilical cavity.

Diameter, 0.46 mm.

This species is a most cosmopolitan one. It is found world wide from the Cretaceous up to and in the recent seas. It is widely distributed in the American Cretaceous. I have identified this as *G. cretacea* rather than *G. dubia* because of its small size and general appearance.

Plesiotype.—Cat. No. 73681, U.S.N.M.

Family ROTALIIDAE

Genus DISCORBIS Lamarck, 1804

DISCORBIS RIPLEYENSIS W. Berry, new species

Plate 3, Figures 16, 17, 18

Test biconvex, smooth, few chambers usually 6–7 in the last formed coil, all visible on the dorsal side, only those of the last formed whorl on the ventral side; periphery margin subcarinate; sutures distinct, those on the dorsal side limbate, even, ventral ones indistinct and slightly limbate near the slight umbo developed on the ventral side; aperture a narrow slit extending backward from the margin toward the umbilical region.

Diameter, 0.50 mm.

This species, which is well characterized, seems closest in its relationship to *D. bertheloti* var. *baconica* Hantken, but differs very much in the sutures and in the degree of convexity. *D. ripleyensis* is easily distinguished by its heavy limbate sutures and margin.

Holotype.—Cat. No. 73682, U.S.N.M.

Genus TRUNCATULINA d'Orbigny, 1826

TRUNCATULINA COONENSIS W. Berry, new species

Plate 3, Figures 1, 2, 3

Test free, biconvex, dorsal side less convex than ventral, peripheral margin slightly rounded and slightly subcarinate, chambers numerous, 9 to 10 in the last coil, involute on ventral side, sutures depressed, slightly distinct, wall punctate; aperture an arched opening at the base of the last formed chamber with a slit extending under the dorsal margin of the chambers.

Diameter, 0.35 mm.

T. coonensis is like *T. vulgaris* Plummer except that it lacks the limbate sutures of that species. It is also somewhat like a form described by Sandidge in manuscript but again it differs in the sutures and in the amount of convexity of the test. *T. coonensis* is fairly common in the Ripley at this point.

Holotype.—Cat. No. 73683, U.S.N.M.

TRUNCATULINA RIPLEYENSIS W. Berry, new species

Plate 3, Figures 4, 5, 6

Test apparently free, small, very unequally biconvex, ventral side being nearly flat, peripheral margin fairly acute but not carinate, chambers numerous, all visible from the dorsal side, the ventral side involute, usually 8–9 in the last coil; sutures level, indistinct except in the last part of the test; surface finely punctate; aperture a simple arched opening at the base of the last chamber.

Diameter, 0.28 mm.

This species, which I have described as new, is probably closely related to *T. tenuimargo* H. B. Brady, but differs in lacking the carinate edge and in other minor respects. *T. ripleyensis* is the smallest *Truncatulina* found in the Ripley at this point and differs, as far as I know, from any others found at other points in the same formation.

Holotype.—Cat. No. 73684, U.S.N.M.

TRUNCATULINA WADEI W. Berry, new species

Plate 3, Figures 13, 14, 15

Test free, biconvex, slightly unequally so, peripheral margin broadly rounded, slightly lobate in young specimens; chambers numerous, 9–10 in the last coil, involute on the ventral, partly so on the dorsal; sutures distinct, depressed on ventral side, slightly limbate on the dorsal face, dorsal surface coarsely punctate, ventral more finely punctate; aperture a simple arched opening at the base of the final chamber.

Diameter, 0.39 mm.

T. wadei is very like *T. akneriana* (d'Orbigny), except that in *T. wadei* the sutures are not as much limbate as in the other species. *T. wadei* is not so coarsely punctate as the other. It is the largest *Truncatulina* found in this material and is easily distinguished from the other species found there.

Holotype.—Cat. No. 73685, U.S.N.M.

Genus ANOMALINA d'Orbigny, 1826

ANOMALINA AMMONOIDES Reuss

Plate 2, Figures 16, 17, 18

Test small, much compressed laterally, composed of numerous chambers, all visible from the dorsal side, only those of the last formed coil visible from the ventral side; ventral side slightly umbilicate, usually about 8 chambers in the last coil, about two and a half to three coils; chambers comma shaped; sutures indistinct becoming more distinct and depressed in the later part of the test; wall fairly heavy, finely perforate; aperture narrow curved slit at the base of the final chamber.

Diameter, 0.40 mm.

This wide spread species is reported by Sandige (MS.) from the Ripley of Alabama and is common in the Ripley material. It has a fairly wide geologic and geographic range and so is of little importance in age correlations.

Plesiotype.—Cat. No. 73686, U.S.N.M.

ANOMALINA TENNESSEENSIS W. Berry, new species

Plate 2, Figures 13, 14, 15

Test small, nautiloid, slightly compressed laterally, composed of numerous chambers all clearly visible from the dorsal side, only those of the last formed coil visible on the ventral side; ventral side umbilicate; about 7–8 chambers in last coil, usually about two coils; sutures slightly depressed, more or less distinct; wall thin, coarsely perforate; aperture a narrow curved slit at base of final chamber.

Diameter, 0.32 mm.

This small species is fairly common in the Ripley. It can be compared to *A. clementina* d'Orbigny in general appearance, but while *A. clementina* has slightly raised ridges on the sutures *A. tennesseensis* has none. In size the two species are nearly alike, *A. clementina* being only slightly larger.

Holotype.—Cat. No. 73687, U.S.N.M.

ANOMALINA NELSONI W. Berry, new species

Plate 2, Figures 19, 20, 21

Test nautiloid, dorsal side nearly flat to slightly concave, ventral side convex; periphery broadly rounded, lobate; chambers numerous, 7–8 in the last formed coil, inflated, gradually increasing in size; sutures distinct, depressed; wall punctate; umbilical cavity usually filled with shell material; aperture an arched slit with a slight lip above it at the base of the last chamber.

Diameter, 0.52 mm.

This species is not common in the material, but is so well characterized that one should not have any trouble in determining it.

Holotype.—Cat. No. 73688, U.S.N.M.

ANOMALINA COONENSIS W. Berry, new species

Plate 2, Figures 22, 23, 24

Test involute, somewhat compressed, nearly equally biconvex, peripheral margin subcarinate; chambers numerous, usually 12 in the last formed coil, very slightly curving; sutures limbate, slightly raised, comma-shaped, slightly elevated at the edge of the umbilical area; wall punctate; aperture an arched slit at the base of the last chamber, extending toward the umbilicus.

Diameter, 0.55 mm.

A. coonensis is by far the most common species of *Anomalina* in this material. It can be compared with *A. ammonoides* Reuss, but is bigger, more equally convex, and has a sharper margin. It is probably fairly closely related to it.

Holotype.—Cat. No. 73689, U.S.N.M.

ANOMALINA WADEI W. Berry, new species

Plate 3, Figures 20, 21, 22

Test nautiloid, dorsal side nearly flat, ventral side strongly convex, periphery subcarinate, slightly lobate; chambers numerous, usually 10 in the last formed coil; sutures in the early portions of the test limbate, later ones depressed, distinct; wall punctate; umbilical cavity usually filled with shell material, small umbo present on ventral side; aperture an arched slit at the base of the last formed chamber, extending toward the umbilical area.

Diameter, 0.52 mm.

This very rare species is somewhat like *A. pseudopapillosa* Carsey, but is larger and the umbilical is filled. *A. pseudopapillosa* is a common form in the Texas and Navarro, but in this material it is absent.

Holotype.—Cat. No. 73690, U.S.N.M.

Genus ROTALINA Lamarck, 1804

ROTALIA BECCARII Linnaeus, var. RIPLEYENSIS W. Berry, new variety

Plate 3, Figures 10, 11, 12

Test round, biconvex, dorsal side lower than ventral, periphery broadly rounded; chambers numerous 11–12 in the last-formed coil, later ones slightly inflate; sutures on the dorsal side slightly curved, later ones strongly depressed, early ones indistinct, on ventral surface indistinct, level; umbilicus open, small; wall smooth, finely punctate; aperture a narrow, elongate slit at the ventral margin of the last chamber and extending to the umbilicus.

Diameter, 0.45 mm.

This variety differs from the parent species in the amount of convexity, it being less convex. It also differs in having a deeper umbilicus. The parent species is common in the Tertiary and is of wide geographic distribution. This variety is fairly common in the Ripley and is very characteristic.

Holotype.—Cat. No. 73691, U.S.N.M.

ROTALIA, species

Test round, biconvex, dorsal side low, ventral face highly convex, periphery rounded, slightly lobate in the later stages, chambers numerous, 8–9 in the last whorl; sutures slightly depressed, early ones filled with clear shell-like material, umbilicus small; wall smooth, finely punctate; aperture destroyed.

This fragment seems to be closest to *R. soldanii* d'Orbigny, but there is so little left that correct determination is impossible.

Family MILIOLIDAE

Genus CORNUSPIRA Schultze, 1854

CORNUSPIRA INVOLVENS Reuss

Plate 1, Figure 6

Operculina involvens Reuss, Denkschr. Akad. Wiss. Wien, vol. 1, 1849, p. 370, pl. 45, fig. 20.

Cornuspira involvens Reuss, Sitz. Akad. Wiss. Wien. vol. 48, 1863 (1864), p. 39, pl. 1, fig. 2.—H. B. Brady, Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 200, pl. 11, figs. 1–3.—J. A. Cushman, Form. North Pacific Ocean, U. S. Nat. Mus. Bull. 71, pt. 6, 1917, p. 25, pl. 1, fig. 2; pl. 2, fig. 2.

Test biconvex, consisting of a long coiled tubular chamber gradually increasing in diameter; wall smooth; the lines between the various coils usually more or less obliterated by shell material. Aperture simply the end of the tube.

Diameter, about 1.24 mm.

This is a well known Teritary species and, as far as I know, has not been described from the American Cretaceous. It is not common in this material but is well preserved when found. Its large size and white porcellaneous tube cause it to stand out in the matrix.

Plesiotype.—Cat. No. 73693, U.S.N.M.

Genus SPIROLOCULINA d'Orbigny, 1826

SPIROLOCULINA CRETACEA Reuss

Plate 2, Figure 6.

Spiroloculina cretacea REUSS, Ostalpen 72, vol. 26, p. 9.—EGGER, Abh. d. II. Cl. d. k. Akad. d. Wiss. XXI, vol. 1, Abth. 1902, p. 21, pl. 1, figs. 22–24.—FRANKE, Abh. geol.-paleon. Inst. Univ. Greifswald, vol. 6, 1925, p. 9. pl. 1, fig. 9.

Test in side view elliptical, in end view the sides are nearly parallel, the periphery flattened; chambers numerous; the periphery and inner margins of the chambers slightly raised, apertural end of the chamber forms a slight neck; lip slightly developed; aperture nearly circular, tooth either undeveloped or else broken off in all specimens, wall smooth, dull.

Length, 0.59 mm., width, 0.39 mm.

This form, which is represented here by one specimen, has only been reported from the Cretaceous. It is extremely rare and although there are a few apparent fragments of it in the material they are all so delicate that they could not be saved. It has not been previously reported from the Cretaceous of the United States, only from Europe.

Plesiotype.—Cat. No. 73694, U.S.N.M.

Genus QUINQUELOCULINA d'Orbigny, 1826

QUINQUELOCULINA SEMINULUM (Linnaeus)

Plate 2, Figures 11, 12

Serpula seminulum LINNAEUS, Syst. Nat., ed. 12, 1767, p. 1264, No. 791.

Miliolina seminulum H. B. BRADY, Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 157, pl. 5, figs. 6 *a–c*.

Quinqueloculina seminulum CUSHMAN, Foram. N. Pacific Ocean, U. S. Nat. Mus. Bull. 71, pt. 6, 1917, p. 44, pl. 11, fig. 2; text fig. 29.

Test free, elongate, about twice as long as broad, smooth, peripheral margin acute, almost carnate, sutures distinct, apertural end raised in a straight neck, aperture broadly oval; there is no tooth apparent.

Length, 0.57 mm.

This species has a very mixed synonymy and is usually used to include all the smooth forms of the genera. I have used it in the same

sense as Brady and Cushman. In my specimens the tooth is not present, having apparently been broken out.

Plesiotype.—Cat. No. 73695, U.S.N.M.

QUINQUELOCULINA WADEI W. Berry, new species

Plate 2, Figures 4, 5

Test free, small, nearly as broad as long, smooth, highly polished, peripheral margins broadly rounded, sutures distinct, apertural end forming a very slight neck, aperture fairly large, tunnel shaped with a simple tooth rounded at the free end.

Length, 0. 28 mm.

This small species is rare but wonderfully preserved, the high polish making it look like a recent form. It seems to be related to *Q. circularis* Bornemann, but has a simple tooth, whereas *Q. circularis* has a broad, rectangular tooth.

Holotype.—Cat. No. 73696, U.S.N.M.

QUINQUELOCULINA COONENSIS W. Berry, new species

Plate 2, Figures 8, 9

Test free, about twice as long as broad, smooth, peripheral margin rounded but bearing a prominent ridge of costae, sutures distinct; apertural end slightly elongated; aperture fairly large, slightly egg-shaped, oval, with no tooth developed.

Length, 0.55 mm.

This fairly common species seems to be related to *Q. bicornis*, (Walker and Jacob), but is smaller and does not have the double costae or such a long neck.

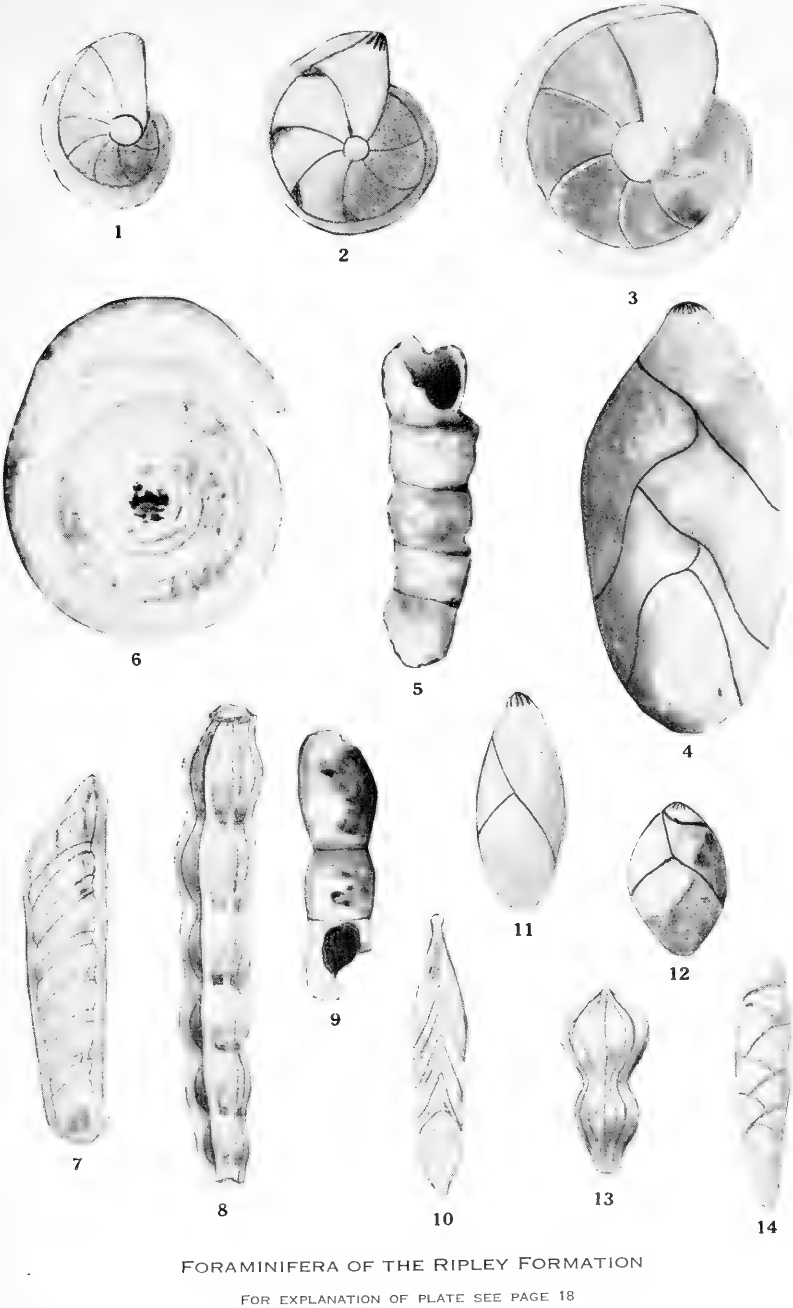
Holotype.—Cat. No. 73679, U. S. N. M.

EXPLANATION OF PLATES

Plate 1

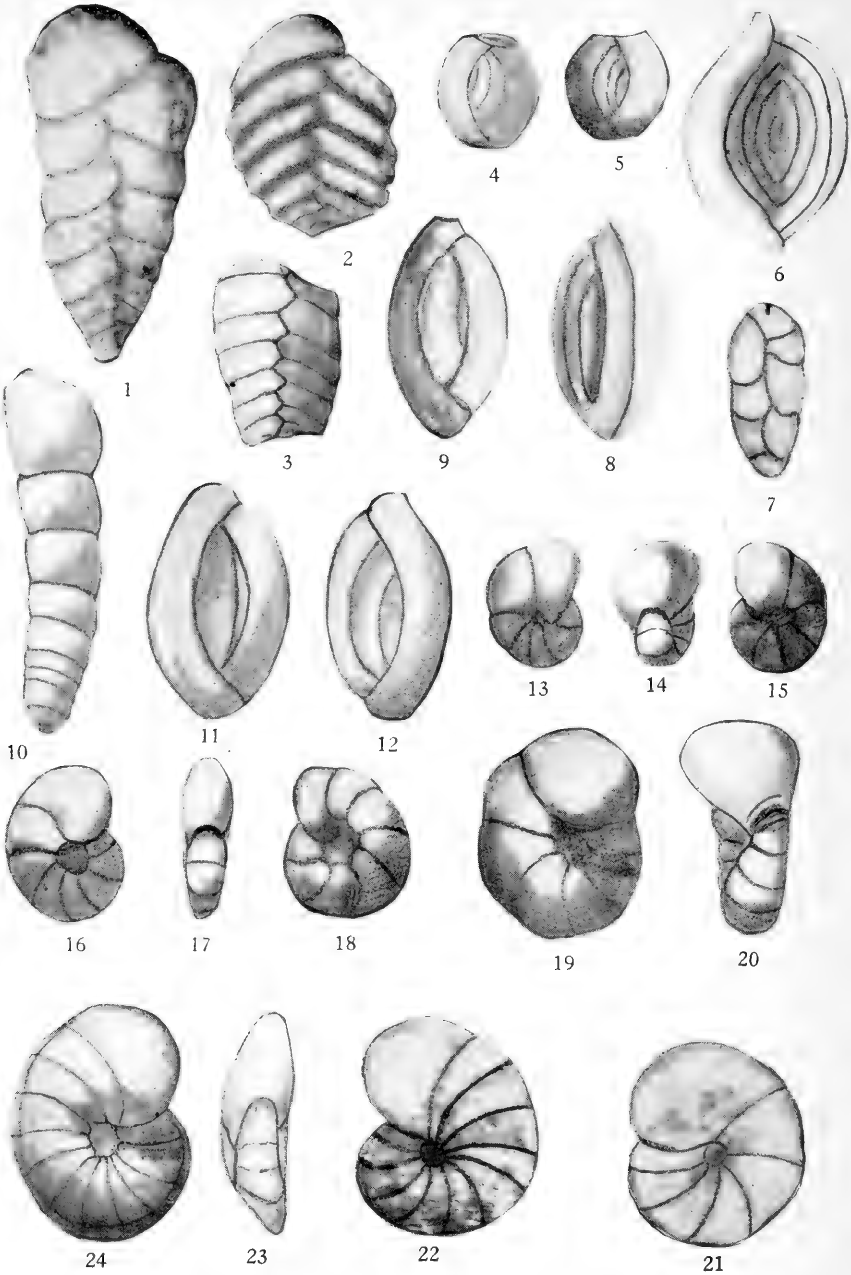
Figures enlarged 37 times

Figure 1. *Cristellaria wadei* W. Berry.
2. *Cristellaria orbicularis*, var. *minuta* W. Berry.
3. *Cristellaria midwayensis* Plummer.
4. *Polymorphina ampla* Karrer.
5. *Reophax cylindricus*, var. *ripleyensis* W. Berry.
6. *Cornuspira involvens* Reuss.
7. *Vaginulina wadei* Kelley.
8. *Nodosaria affinis* d'Orbigny.
9. *Nodosaria*, species.
10. *Frondicularia angustissima* Reuss.
11. *Polymorphina gutta* d'Orbigny.
12. *Polymorphina lactea*, (Walker and Jacobs).
13. *Nodosaria proxima* Silvestri.
14. *Bolivina plaita* Carsey.



FORAMINIFERA OF THE RIPLEY FORMATION

FOR EXPLANATION OF PLATE SEE PAGE 18



FORAMINIFERA OF THE RIPLEY FORMATION

FOR EXPLANATION OF PLATE SEE PAGE 19

Plate 2

Figures enlarged 55½ times

Figure 1. *Textularia agglutians* d'Orbigny.
2. *Textularia ripleyensis* W. Berry.
3. *Textularia sagittula*, var. *coonensis* W. Berry.
4–5. *Quinqueloculina wadei* W. Berry.
6. *Spiroloculina cretacea* Reuss.
7. *Bulimina quadrata* Plummer.
8–9. *Quinqueloculina coonensis* W. Berry.
10. *Dentalina communis* d'Orbigny.
11–12. *Quinqueloculina seminulum* (Linnaeus).
13–15. *Anomalina tennesseensis* W. Berry.
16–18. *Anomalina ammonoides* Reuss.
19–21. *Anomalina nelsoni* W. Berry.
22–24. *Anomalina coonensis* W. Berry.

PLATE 3

Figures enlarged 55½ times

FIGURES 1–3. *Truncatulina coonensis* W. Berry.
4–6. *Truncatulina ripleyensis* W. Berry.
7–9. *Globigerina cretacea* d'Orbigny.
10–12. *Rotalia beccarii*, var. *ripleyensis* W. Berry.
13–15. *Truncatulina wadei* W. Berry.
16–18. *Discorbis ripleyensis* W. Berry.
19. *Lagena sulcata*, var. *semiinterrupta* W. Berry.
20–22. *Anomalina wadei* W. Berry.
23. *Reophax coonensis* W. Berry.

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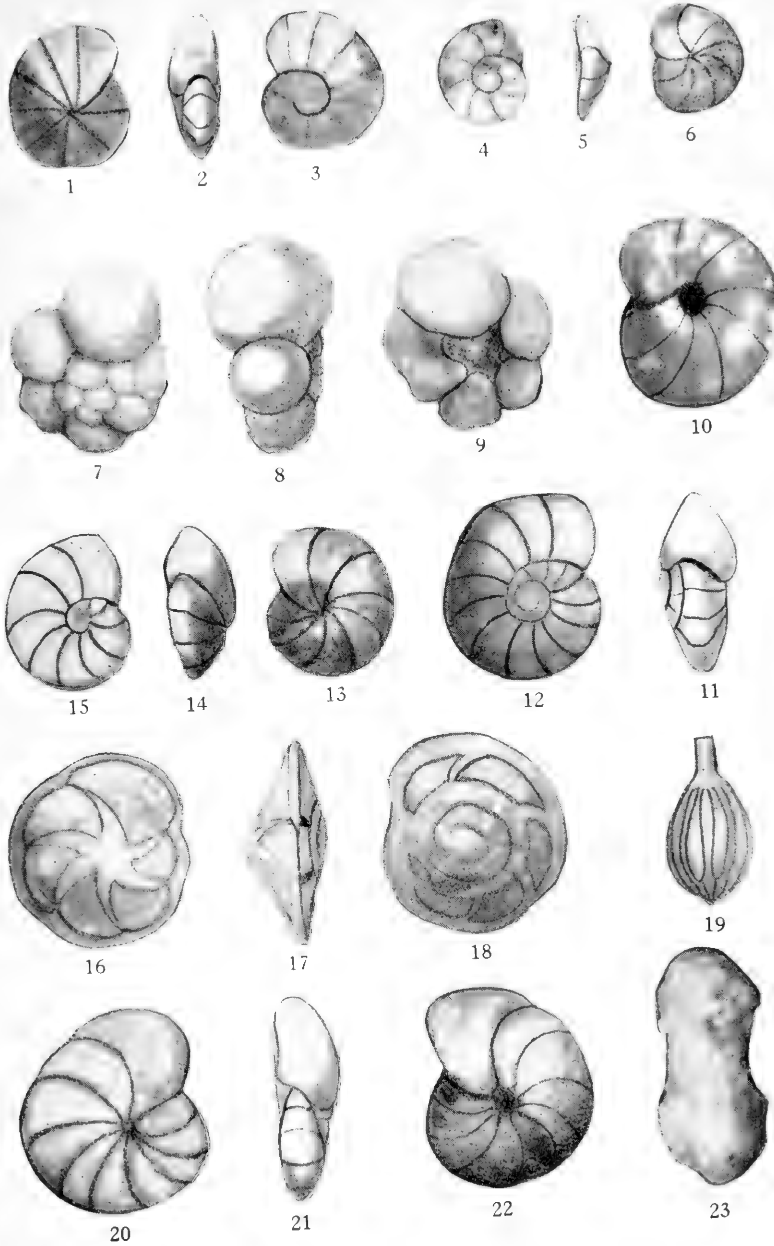

FORAMINIFERA OF THE RIPLEY FORMATION

FOR EXPLANATION OF PLATE SEE PAGE 20

NOTES ON THE MUSCOID FLIES OF THE GENERA OPELOUSIA AND OPSODEXIA WITH THE DESCRIPTION OF THREE NEW SPECIES

By H. J. Reinhard
Of College Station, Tex.

During March, 1921, while collecting Diptera at College Station, my attention was drawn by the presence of several small snails which were situated on tree trunks, 3 or 4 feet above the ground. The snails appeared normal and were quite firmly attached to the surface, but upon removing a specimen it was found to contain a dipterous puparium. Further search resulted in taking 16 additional parasitized specimens, each with a single puparium located in the basal end of the chamber. The puparia were placed in breeding cages and 5 male and 12 female flies issued from March 30 to April 15. Judging from the early date of collection, it appears more than likely that this parasitic fly hibernates in the pupal stage within the shell of its host. Examples of the snail were sent to the United States National Museum, where they were determined and accessioned as *Succinea luteola*. Recently Dr. J. M. Aldrich determined the parasite reared from this mollusk as *Opelousia obscura* Townsend.

Genus OPELOUSIA Townsend

The genus *Opelousia* Townsend, with *obscura* (new species) as the type, was erected in 1919 [1] for the reception of four male specimens collected at Opelousas, La., and Fargo, N. Dak. Since the original characterizations are brief, lacking in essential data, and do not include the female, a description of this sex is included below with the description of an apparently new species.

OPELOUSIA OBSCURA Townsend

Opelousia obscura Townsend, Proc. U. S. Nat. Mus., vol. 56, 1919, p. 547.

Female.—Blackish brown, thinly cinereous pollinose, subshining. Eyes bare. Front 0.34 of head width (average of six, 0.34, 0.38, 0.33,

[1] Proc. U. S. Nat. Mus., vol. 56, p. 547.

0.33, 0.36, 0.33); inner orbits parallel from vertex to base of antennæ. Parafrontal wider than median vitta, which is blackish and extends on each side of ocellar triangle to inner vertical. Ocellars small, proclinate. Inner and outer verticals well developed. Frontals in two rows stopping at base of antennae. Orbitals two pairs. Antennae brown, tinged with yellow basally, second joint about one-half length of third, which is straight on the anterior edge and densely covered with whitish pubescence. Arista brownish, thickened only near base, sparsely short-haired on upper side about halfway to tip, basal joints short. Parafacials silvery, bare, narrow, diverging strongly below. Vibrissae at oral margin usually with one strong and several smaller bristles above on facial ridges, which are rounded and flattened. Facial depression rather shallow and slightly convex but without a carina. Proboscis short, fleshy. Palpi yellow to brownish black, smaller than usual, little or not at all thickened apically, with several black bristles near the apex. Cheeks about one-fourth the eye height, thinly pollinose on a reddish background, with a few short black bristles above the lower marginal row. Occiput cinereous pollinose with only short black bristles.

Thorax and scutellum black, thinly pollinose, subshining, two narrow vittae indistinctly visible before suture. Chaetotaxy: Acrostichal 0, 1; dorsocentral 2, 3; humeral 2; posthumeral 1; presutural 1; notopleural 2; supraalar 3 (small except middle one); intraalar 2; postalar 2; sternopleural 2; pteropleural 0; scutellum with one large lateral and a decussate apical pair; postscutellum small; infrasquamal hairs present; halteres yellow; calypters white.

Abdomen with cinereous pollen tinged with brown on the subshining posterior margins of the first three segments. First segment without median marginals; intermediate segments each with a complete marginal row, no discal; fourth segment with a discal and a marginal row; genital segments blackish basally and yellow apically, without piercer.

Legs brownish yellow, except tarsi which are black; middle tibia with one bristle on outer front side beyond middle; claws and pulvilli short.

Wings subhyaline, rather short and broad to tip; veins yellow, bare except third, which has one large and a few small bristles at the base; costal spine moderately long, usually doubled; fourth vein broadly curved, bend without a definite angle; first posterior cell open or barely closed at or just before tip; hind cross vein about midway between bend and small cross vein; last section of fifth vein about one-fifth the preceding.

Length, 5 to 7 mm.

Described from 24 females reared and collected at College Station, Tex., April to November (H. J. Reinhard); and 1 female collected at San Antonio, Tex., June 21, 1928 (H. B. Parks). The abdomen of the latter specimen was crushed at the time it was pinned and the protruding larvipositor contains a partially visible shriveled white maggot. Additional locality records include La Fayette, Indiana (J. M. Aldrich), and Sugar Grove, Ohio, one male taken June 8, 1926 (D. G. Hall).

OPELOUSIA FLAVESCENS, new species

Male.—Eyes bare. Front very narrow above before ocelli hardly as wide as ocellar triange; vitta narrow, triangular below and reduced to a line posteriorly, brownish black; parafrontals shining silvery, blackish on the inner margins along the vitta. Frontals in two slightly diverging rows of six to eight short erect bristles barely extending to base of antennae, the uppermost pair hairlike, situated a short distance below the lower ocellus, a few inconspicuous black hairs in the rows but none extending on the parafacials. Inner verticals well developed, outer ones small and hairlike. Ocellars small, proclinate, not divergent; postocellars almost equally strong. Orbitals none. Parafacials shining silvery, bare, diverging strongly below, about equal to width of third antennal segment. Facial depression with cinereous pollen on blackish background, not keeled. Vibrissae large, situated at oral margin, with two or three small bristles above on facial ridges which are rounded and decidedly flattened. Antennae about three-fourths of the length of the face; third joint brown, tinged with yellow basally, especially on inner side, densely covered with white pubescence; second joint entirely yellow, about one-half the length of third. Arista yellowish, slender beyond the very briefly thickened base, sparsely short-haired on upper side about halfway to tip, a few inconspicuous hairs on underside, basal joints short but quite distinct; cheeks about one-fifth the eye height, with only a few scattered short bristles below, densely covered with cinereous pollen. Occiput black, with thin gray pollen, sparsely covered with short black hairs. Proboscis very short, labella large, yellow. Palpi yellow, rather small, apex but slightly thickened, bearing a few black bristles.

Thorax and scutellum black, subshining, the cinereous pollen on mesonotum distinctly tinged with brown, dorsal vittae indistinct. Chaetotaxy: Humeral 2; posthumeral 1; presutural 1; notopleural 2; acrostichal 0, 1 (slightly anterior to hindermost dorsocentrals); dorsocentral 2, 3; intraalar 2; supraalar 3 (small except middle one); postalar 2; sternopleural 2; pteropleural 0; scutellum with two large diverging laterals distinctly nearer the apex than base, between these a smaller decussate apical pair, and usually an addi-

tional weak sublateral and small preapical pair present; postscutellum small; halteres yellow; calypters white; infrasquamal setules present.

Abdomen rather slender, two basal segments either faintly or pronounced yellowish on the sides, otherwise black, subshining; hairs on dorsum erect;entirely covered with cinereous pollen which is thinner on the narrow hind margins of the segments; when viewed from behind a narrow dorsal vitta present which becomes wider basally; first segment with a row of weak marginals which may be hairlike or incomplete above; intermediate segments each with a complete marginal row, no true discal bristles present, although the erect hairs often resemble discals on these segments; fourth segment with a complete marginal and a discal row; venter with long bristly hairs. Genitalia small, outer forceps broad lobelike brownish black, inner forceps yellowish, slender, not divergent, tips black; penis yellow basally, distal segment black, apex expanded in a circular lobe with a narrow whitish border; fifth abdominal sternite prominent, deflected downward, broadly incised, bearing fine black hairs on the lateral margins.

Legs yellow basally, tarsi black; middle tibia with one short bristle on outer front side distinctly beyond the middle; claws and pulvilli nearly as long as last tarsal joint.

Wings subhyaline; veins yellow, third with two or three bristles near base, all others bare; fourth vein broadly curved without a definite angle or stump, nearly straight beyond bend; first posterior cell narrowly open in the wing tip; hind cross vein perpendicular to fourth vein, about equidistant from bend and small cross vein; last section of fifth vein very short, hardly one-fifth the preceding section; costal spine present, usually prominent and doubled.

Female.—Front 0.32 of head width (average of six, 0.33, 0.30, 0.33, 0.31, 0.35, 0.33); inner orbits parallel from vertex to base of antennae; vitta brown, about one-half the width of parafrontals, which are thinly gray pollinose reflecting blackish above; the usual two pairs orbitals present; the uppermost frontals large and directed posteriorly outward; outer verticals about one-half as long as the inner ones; antennae, thorax, scutellum, and abdomen more yellowish and wings broader than in male. Genital segments as in *obscura.*

Length: Male, 5 to 6.5 mm.; female, 4.5 to 6.5 mm.

Described from 10 males and 8 females, all collected at College Station, Tex., March to June, 1919–1928 (H. J. Reinhard).

Type.—Male, Cat. No. 41985, U.S.N.M. Four paratypes, including both sexes, also deposited in the National Museum.

This species is very closely allied to the genotype *obscura*, from which it differs in the very narrow front of the male, the yellow ab-

domen in the female and yellow legs in both sexes. The host relationships of *flavescens* are unknown.

Genus OPSODEXIA Townsend

Townsend established the genus by the mere designation of a type species[2] without giving any description of the generic characters. The type of *Opsodexia* is *Chaetona bicolor* Coquillett. I am indebted to Dr. J. M. Aldrich for pointing out these facts to me in correspondence and placing two apparently undescribed species at my disposal.

Generic characters, from the type species.—Postscutellum only slightly developed and membranous above. Occiput somewhat swollen below; cheeks one-fourth the eye height. Front in male greatly narrowed above; frontals in two rows, stopping at base of antennae, the uppermost hairlike situated considerably before anterior ocellus. Antennae inserted slightly below middle of eye, slightly shorter than face, third joint three times the length of second; arista with long hair above and beneath. Face not keeled; ridges flattened below, with a few short bristles above vibrissae, which are well developed and situated on level with oral margin; parafacials narrow, with short hairs above. Proboscis short, fleshy; palpi normal. Eyes bare.

Thoracic chaetotaxy: Dorsocentral 2, 3; acrostichal 0, 1 (in transverse line with hindmost pair of dorsocentrals); humeral 2; posthumeral 1; presutural 1; notopleural 2; pteropleural 0; supraalar 3 (posterior one bairlike); intraalar 2 (none near suture); postalar 2; sternopleural 2; scutellum with one marginal pair near base, a strongly developed decussate apical pair, and a pair of rather weak preapical and discal; disk with numerous erect fine hairs.

Abdomen without discal macrochaetae except on fourth segment; segments 2 to 4 with marginal rows; first without median marginals. Wings normal; fourth vein with an oblique bend ending at or just before apex; hind cross vein oblique to fourth, which it joins slightly nearer the bend than small cross vein; last section of fifth vein very short.

The genus resembles *Opelousia* in having a short fleshy proboscis; flat unkeeled face; front of male greatly narrowed above without any frontal bristles immediately before triangle, the uppermost being very small; a conspicuous patch of infrasquamal hairs; no presutural acrostichals, etc. It differs principally in the slight development of the postscutellum, arista with longer and denser hairs; hind cross vein less erect; parafacials with short hairs above.

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[2] Proc. Biol. Soc. Wash., vol. 28, p. 20, 1915.

KEY TO SPECIES OF OPSODEXIA

1. Abdomen yellow ---------- **bicolor** Coquillett.
   Abdomen black ---------- 2.
2. Legs yellow; abdomen without discals; wings hyaline. **abdominalis**, new species.
   Legs black; abdomen with discals; wings distinctly infuscated. **cruciata**, new species.

OPSODEXIA ABDOMINALIS, new species

Male.—Front at narrowest part 0.11 of head width; parafrontals silvery, narrowed before vertex and widening rapidly below, with a few short inconspicuous hairs outside the frontal rows; median stripe blackish, considerably broader than the parafrontal at base of antennae, greatly narrowed posteriorly but distinctly wider than the anterior ocellus; frontals in two diverging rows of six or seven rather short bristles, stopping at base of antennae, the uppermost pair hairlike and situated some distance before the ocellar triangle, which bears a pair of strong, proclinate, nondivergent bristles midway between the anterior and posterior ocelli, several long bristles present on posterior margin of triangle; orbitals none; inner verticals well developed, curving posteriorly; parafacials strongly divergent below, shining silvery, with one or two short hairs on upper extremity, about equal to width of third antennal joint; facial depression shallow, without a carina, densely gray pollinose on reddish background; ridges flattened below, becoming sharp and more prominent above, with one strong and several weaker bristles above vibrissae, which are situated on level with oral margin; antennae three-fourths the length of face, basal joints yellow, third joint blackish, pubescent, about twice the length of second joint; arista yellowish beyond the briefly thickened black base, with moderately long hair on upper side extending more than halfway to tip, and a few short inconspicuous hairs beneath near the base, penultimate joint longer than broad; proboscis short, fleshy; palpi black, smaller than usual, hardly thickened apically; cheeks one-fourth the eye height, very thinly gray pollinose on red ground color; occiput somewhat swollen below, covered with a thin layer of gray pollen and bearing only short black bristly hairs arranged in irregular rows above; eyes bare.

Thorax and scutellum black, with rather uniform gray pollen which appears denser when viewed from the front; mesonotum, except immediately in front of transverse suture, subshining in rear view, without any distinct vittae. Chaetotaxy: Humeral 2; posthumeral 3; presutural 1; notopleural 2; pteropleural 0; acrostichal 0, 1 (in transverse row with posterior dorsocentrals); dorsocentral 3, 3 (anterior slightly outside the row); intraalar 3 (anterior

one hairlike); supraalar 3; postalar 2; sternopleural 2, 1; scutellum with two pair of lateral bristles, the posterior ones largest; a well-developed decussate apical pair; preapical pair also well developed; discal pair hairlike; postscutellum only slightly developed, membranous above; infrasquamal hairs present; halteres yellow; calypters tawny.

Abdomen black, with dense gray pollen that extends to the hind margins of all segments, black reflecting spots on segments 3 and 4 and a narrow dark vitta widening basally apparent when viewed from behind; first segment with a row of marginal bristles which are hairlike or incomplete above; segments 2 and 3 each with a complete marginal row, no discals present; fourth segment with a marginal row and numerous almost equally strong irregularly placed discals; first genital segment rather large, black, tinged faintly with yellow apically, a narrow shining black transverse band crossing the middle, otherwise thinly gray pollinose; fifth sternite unusually prominent, deflected downward at a rather sharp angle, with a broad U-shaped incision, the lobes thickly covered with rather fine short black hair; genitalia not in position to examine.

Legs yellow, except tarsi, which are black; claws and pulvilli elongated; middle tibia with one bristle on the outer front side; hind tibia not ciliate.

Wings large, normal shape, tinged with yellow at base and along costal margin; all veins light yellow, bare, except third, which has three or four short black bristles at the base; fourth vein broadly curved without a definite angle at bend, ending at wing tip, narrowly closing first posterior cell; hind cross vein about midway between bend and small cross vein; costal spine distinct, doubled.

Length, 7 mm.

Described from one male received from Dr. J. M. Aldrich, collected August 19, 1914, Fabyans, N. H. (C. H. T. Townsend), on flowers of *Solidago*.

Type.—Male, Cat. No. 41986, U.S.N.M.

The black densely gray pollinose abdomen readily separates the species from *bicolor*. It differs further from that species by having the fourth vein broadly bowed without a definite angle, arista with shorter hairs above and practically bare beneath, etc.

OPSODEXIA CRUCIATA, new species

Male.—Front greatly narrowed above and hardly as wide as ocellar triangle; median stripe blackish, triangular below, reduced to a line posteriorly, extending on each side of triangle to inner vertical; parafrontals narrow above, widening almost to width of the median stripe at base of antennae; frontals in two rows of about eight bris-

tles hardly extending to base of antennae, the two uppermost pairs larger than the median ones and cruciate near base, the anterior bristles very weak, the pair above these fully as strong as the vibrissae, horizontal, cruciate at middle; ocellars very minute, proclinate; orbitals none; inner verticals well developed, erect, cruciate near tip, the outer ones hairlike; parafacials gray pollinose, with a few short inconspicuous hairs above, at narrowest point about two-thirds the width of third antennal joint; face shallow, not keeled; ridges rather flattened, with a few bristles above vibrissae, which are situated about on level with oral margin; antennae slightly shorter than the face, yellowish, infuscated apically, third joint about two and one-half times the length of second; arista of moderate length, yellowish, slightly thickened at base, with long hairs above extending from base to tip, beneath bare at the base with shorter hairs beyond extending to tip, penultimate joint broader than long; proboscis short, fleshy, labella large; palpi blackish, rather short, the slightly thickened apex bearing a few short bristles; cheeks one-fifth the eye height, thinly gray pollinose, with numerous black hairs below; occiput gray pollinose, practically bare above, with sparse black and pale hairs below; posterior orbits gray pollinose, reduced to a line on either side of vertex; eyes bare.

Thorax and scutellum black, with gray pollen; (the mesonotum discolored, dorsal stripes probably distinct). Chaetotaxy: Humeral 3 (the inner one small); posthumeral 1; notopleural 2; pteropleural 0; presutural 2 (outer large, inner small); acrostichal 1, ? (obscured by pin); dorsocentral 2, 3; sternopleural 2; scutellum with two pairs of laterals, the posterior ones broken off but evidently large and divaricate; the apical pair also broken off but the large scars indicating strong bristles; a pair of rather weak preapical and discal bristles present, the latter wide spaced on disk which bears a number of erect fine hairs on basal margin; postscutellum very small; posterior calypters brown, anterior ones white; infrasquamal hairs present; halteres brownish.

Abdomen black, with gray pollen extending over broad bases of segments 2 to 4 except on a very narrow dark median stripe, viewed from behind the pollen is changeable and has a distinct brownish tinge; first segment without median marginal bristles; intermediate segments each with a pair of discal and a marginal row; fourth with a marginal row and irregular placed discals; genital segments black, small; outer forceps lobelike, black basally, tips yellowish, broadly rounded; inner forceps widely divergent, moderately broad at base tapering to rather sharp tips which are yellowish, otherwise black; fifth sternite normal, with a rather shallow broad V-shaped incision, lobes bearing numerous fine black hairs.

Legs black, all the claws and pulvilli enlarged, the latter whitish; hind tibia with three bristles near base, middle, and apex on the outer posterior edge, and three on the hind side spaced about as the former; middle tibia with one small bristle on outer front side considerably beyond the middle.

Wings distinctly infuscated throughout; third vein with four or five bristles at base, all others bare; fourth vein with a rounded bend almost straight beyond, closing the first posterior cell rather narrowly just before the apex; hind cross vein bowed near middle, about midway between bend and small cross vein; costal spine distinct.

Length, 5.5 mm.

Described from one male specimen received from Dr. J. M. Aldrich collected at Havana, Cuba (Baker).

Type.—Male, Cat. No. 41987, U.S.N.M.

This species is not so closely related to the genotype as *abdominalis*, but is referred here principally because it has about the same type of postscutellum as *bicolor*. The main characters in which it differs are the presence of anterior acrostichals, and the large horizontal cruciate frontals above base of antennae.

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ORDOVICIAN TRILOBITES OF THE FAMILY TELEPHIDAE AND CONCERNED STRATIGRAPHIC CORRELATIONS

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INTRODUCTION

Previous work on Telephus.—The genus *Telephus* was established by Barrande[2] for the Bohemian species *T. fractus.* Of this species Barrande knew only the cranidium and the pygidium, and of the former he mistook the long palpebral bands for the border of the cheeks. Consequently he expressed himself as quite unable to place the genus in his classification of the trilobites. Two years later Angelin[3] described three species from Ordovician formations in Norway and Sweden but added nothing toward fixing the systematic position of *Telephus.* Some years later Billings[4] recognized the genus on the west side of the Atlantic but, like his predecessors in the field, failed to add anything of more than specific importance to what had been known before. Many years later Reed[5] described a cranidium from the Girvan District in Scotland that he regarded as specifically identifiable with the Bohemian *T. fractus.* In 1909 he described a new species, *T. hibernicus*, from an Ordovician formation in Ireland, and five years later[6] in the supplement to his mono-

[1] This is one of many papers on trilobites for which the author has worked out the facts in the past 25 and more years but lacked the time to complete the manuscripts and illustrations. Most of these unpublished works endeavored to present what was known at the time of the species of a particular genus or family. At the earnest and repeated solicitation of friends it is now planned to bring to date and publish as many of these old manuscripts as possible without interfering too greatly with the paramount duty of completing the long promised monographs on the Ozarkian and Canadian systems. The present installment has become possible mainly through the gratefully accepted aid of Dr. C. E. Resser, who made most of the photographs and assisted otherwise in promoting the effort. The originally brief discussion of the stratigraphy of the beds in which species of *Telephus* occur has been greatly expanded and completely rewritten, so that in the writer's opinion it has become the more important part of the paper.

[2] Barrande, Joachim, 1852, Syst. Sil. du centre Boheme, vol. 1, p. 890.

[3] Angelin, N. P., 1854, Palaeontologia Scandinavica, p. 91.

[4] Billings, E., 1865, Paleozoic fossils: Canada Geol. Survey, vol. 1, p. 291.

[5] Reed, F. R. Cowper, 1903, Paleontogr. Soc., p. 44.

[6] Reed, F. R. Cowper, 1909, Geol. Soc. London Quart. Journ., vol. 65, p. 149; 1913, Paleontogr. Soc., vol. 67, p. 16.

graph he described another new and very different species (*T. salteri*), from the Balclatchie group of Scotland.

Except Barrande none of the mentioned authors even discussed the generic relations of *Telephus*. The first to give us anything like a true estimate of these relations was Hadding,[7] who, in a paper specially devoted to the species of *Telephus* known in 1913, supplied much desired information concerning the palpebral lobes, eyes, and free cheeks. On the basis of these new data he endeavored to show the previously unsuspected relations of the genus to the Aeglinidae, on the one hand, and the Remopleuridae, on the other. Still, he found sufficient differences to convince him that *Telephus* represents a family of its own.

In 1905 I found my first cranidium of a *Telephus* in the Appalachian Valley. It and others procured at the same time were found in a dark subcrystalline limestone—on Reservoir Hill, near Lexington, Va.—that is now known to represent the Whitesburg limestone [8] of Tennessee. The outcrop near Lexington was discovered some years before and recommended to me as containing an abundant and at that time strange fauna by Prof. H. D. Campbell of Washington and Lee University. During the course of my stratigraphic work in the Appalachian Valley since 1905 many other occurrences of *Telephus* were found in southwestern Virginia, Tennessee, and Alabama. Most of these were in the horizon of the Whitesburg limestone which, when present at all, lies just beneath the base of the Athens shale and in places rests on the Holston marble. In Virginia the latter was known for a time by the now unnecessary name Murat limestone. Above the Whitesburg the genus is represented by five species in the Athens shale and by three other species in the next overlying Tellico formation.

Character of material.—As in Europe and Canada the southern Appalachian species of *Telephus* also are represented mainly by cranidia. No complete specimens have been found, and the separated free cheeks, pygidia, and thoracic segments that were observed are surprisingly few. Moreover, the descriptions of the cranidium given by Barrande, Angelin, and Billings misled us as to the nature of

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[7] Hadding, Assar, 1913, Släklet Telephus: Geolg. Fören. I Stockholm Förhandl., pp. 25–48.

[8] The term Whitesburg limestone has been used by me for many years and is now formally proposed for the dark crystalline limestone that at many places in the Appalachian Valley south of Staunton, Va., underlies the dark calcareous Athens shale or limestone. At most places in the valley the Whitesburg rests on the Lenoir limestone, but at Lexington and in the belt that runs along the west base of Walker Mountain just east of Bland, in Virginia, the Holston marble lies between the Whitesburg and the Lenoir. The type locality of the Whitesburg is at, and particularly 2 miles southeast of that town, and 1½ miles southwest of Bulls Gap, Tenn. At the latter place the formation attains a thickness of about 500 feet and rests on the Lenoir. Northwest of Whitesburg the formation pinches out completely in 2 miles. A large and distinctive fauna aggregating about 100 species has been collected from the Whitesburg.

the cheeks and eyes, so that it was only after satisfying myself regarding the free cheeks that belonged to each of the associated trilobites that the few unassigned remaining cheeks began to be considered as probably belonging to *Telephus*. It was in the occasional brief periods of 1908 to 1913 that could be devoted to the study of the Appalachian Ordovician faunas that I worked out the characters and wrote most of the following descriptions of the American species of the genus. Then before my paper could be completed and published Hadding's work on the genus appeared. Though his paper interfered with my slowly maturing plans and delayed publication of my results I am not sorry because so far as it went I know that Hadding's paper was a better contribution to the subject than mine at that time would have been. On the contrary, I was pleased to note that in all essential respects our conclusions were in accord. As regards structural features I differed then and differ now from his view of the two downwardly directed anterior spines, which he claims "are only parts of the cephalic limb intersected by the facial sutures." Possibly this is true of the European species studied by him, and on first sight it appears so also in the American species. However, on closer investigation I found that in all of the latter these are actually hollow spines with subcircular cross-section and separated at their bases by a depression or cleft from a much shorter prominence or angle of the rim against which the inner end of the free cheek abuts. This condition is clearly shown not only by a hundred or more of my specimens but equally well also in the types of *T. americanus* Billings. Text figures reproduced from drawings of a plaster cast of the best of the latter are given in Hadding's paper, but regarding these I can say only that the draughtsman for some unknown reason overlooked the separateness of the spines which is clearly indicated on at least the right side of the specimen (see pl. 2, fig. 23). Under the circumstances I am persuaded that the apparent difference between the American and European species rests on imperfect observation.

REVISED DESCRIPTION OF GENUS TELEPHUS

With the data now in hand the following amended definition of the genus is presented.

Family TELEPHIDAE Angelin

Genus TELEPHUS Barrande

Small, strongly convex and probably slender opisthoparian trilobites, with narrow pleural parts well separated from the relatively wide axis; carapace known only from dismembered parts. Cephalon

usually considerably wider than long, large as compared to the thorax and pygidium, with very large, often bulbous, eyes and narrow rim. Glabella well defined, usually strongly convex, tapering more or less forward, rarely semielliptical to subovate, without lateral furrows but in some species with a dimple near the middle of the lateral slopes and more rarely with smooth ovately outlined spaces that probably represent the posterior and second glabellar lobes of other trilobites. Occipital ring well developed, often crescentic, usually with a median spine that varies greatly in length and strength with the species. Fixed cheeks rather narrow posteriorly, increasing in width anteriorly so that the greatest width is more or less in front of the middle and the outline varies from crescentic to rounded-triangular; outer border made by a concave palpebral band that flattens along the anterior side beyond the eye; area between this band and the dorsal furrow more or less strongly convex, usually rising into a curved ridge. Posterior portion of facial suture directed obliquely outward, backward, and downward around the very small posterior limb to the point only a short distance from the dorsal furrow at which it cuts the posterior margin. Anterior part of facial suture beyond the eye closely following the anterior edge of the cephalon to a small projection of the rim which it cuts to reach the edge. Between these slightly projecting points the anterior rim is emarginated and the excavation divided unequally into three concave parts by two hollow spines that are highly characteristic. These spines sometimes project directly forward, but more commonly they curve gradually or more abruptly downward. The cavities on their outer sides are smaller than the median emargination and as a rule partly bottomed by shell. Free cheeks consist mainly of very large bulbous or somewhat crescentiform eyes separated on the outer side by a narrow deep groove from a narrow wirelike rim that broadens more or less near or somewhat in front of the middle of its posterior half to give sufficient lodgment for the base of a genal spine. This spine varies greatly in size and direction. Rarely it is weak and short, oftener strong, long and curved and directed outward at varying angles; and in one case it rises directly upward from the rim and curves over the eye. Occasionally a smaller though otherwise similar spine occurs a short distance behind the genal spine. The eyes, as said, are very large and more or less strongly convex, and numerously facetted as in *Aeglina*, and in some cases at least must have been set on the head so that in a dorsal view of the animal the outer rim of the cheek would be almost covered by the periphery of the eye. In such cases the genal spines are very small or wanting, as in *T. mysticensis*, or they are turned up beside and doubtless beyond the top of the eye, as in *T. pustulatus*. Facettes on eyes ar-

ranged in quincunx, varying greatly in size and number, in some as few as 15 transverse rows, in others as many as 50 rows between base and top of eye.

Thorax with broad axis, well defined dorsal furrows, and narrow pleural areas; axial part of segments each with a single or two closely approximated short, backwardly directed nodes or spines; pleural part of segments grooved, outer extremity more or less acuminate. Number of segments unknown.

Pygidium small, subtriangular to subpentagonal; axis strongly convex, sharply defined, wide in front, tapers rapidly and extends nearly to the posterior extremity; pleural lobes narrow, practically unsegmented; axis with two, rarely three, rings, all with one or two median spines, the second and third usually with a small post-lateral node on each side. General appearance of pygidium varies considerably in different species, the difference being in details rather than essential respects. The posterior edge may be simply rounded or drawn out into a flat median spine.

Genotype.—Telephus fractus Barrande.

Stratigraphic range.—Ordovician and earliest Silurian.

Origin and center of dispersal.—Middle Atlantic realm.

Geographic distribution as in the following tabulation of species:

GEOGRAPHIC DISTRIBUTION AND STRATIGRAPHIC POSITION OF SPECIES OF TELEPHUS

European species

Telephus fractus Barrande, Bohemia, D 4 and D 5.

Telephus granulatus Angelin, Norway and Sweden, upper half Ogygiocaris shale.

Telephus bicuspis Angelin, Norway and Sweden, lower half Ogygiocaris shale.

Telephus haddingi, new species, Sweden, lower half Ogygiocaris shale.

Telephus wegelini Angelin, Sweden, Trinucleus shale.

Telephus mobergi Hadding, Sweden, base of Ogygiocaris shale.

Telephus linnarssoni, new species, Delarne, Sweden, Leptaena limestone.

Telephus hibernicus Reed, Ireland, Tourmakeady Beds.

Telephus reedi, new species, Girvan District, Scotland, Whitehouse group.

Telephus? salteri Reed, Girvan District, Balclatchie group.

American species

Telephus americanus Billings, Newfoundland. Div. N and P.

Telephus mysticensis, new species, Mystic, Quebec, probably Blount age.

Telephus mysticensis simulator, new variety, Mystic, Quebec, probably Blount age.

Telephus bicornis, new species, Bland County, Virginia, Whitesburg limestone.

Telephus gelasinosus Ulrich, Pratts Ferry, Alabama, Whitesburg limestone.

Telephus pustulatus, new species, Lexington, Virginia, Whitesburg limestone.

Telephus latus, new species, near Saltville, Virginia, Athens shale.

Telephus spiniferus, new species, near Saltville, Virginia, Athens shale.

Telephus spiniferus calhounensis, new variety, Calhoun, Tennessee, near top of Athens.

Telephus sinuatus, new species, Lexington, Virginia, Whitesburg limestone.

Telephus bipunctatus, new species, Virginia, Tennessee, and Alabama, Whitesburg limestone.

Telephus impunctatus, new species, Tennessee and Alabama, Whitesburg limestone.

Telephus prattensis, new species, Tennessee and Alabama, Whitesburg limestone.

Telephus tellicoensis, new species, Knoxville, Tennessee, Tellico formation.

Telephus transversus, new species, near Knoxville, Tennessee, Tellico formation.

Telephus hircinus, new species, near Knoxville, Tennessee, Tellico formation.

Telephus bilunatus, new species, near Albany, Tennessee, Whitesburg limestone.

Telephus troedssoni Raymond, Athens, Tennessee, and Longview, Alabama, Athens shale.

Telephus buttsi, new species, near Longview, Alabama, Athens shale.

SYSTEMATIC POSITION OF TELEPHUS AND RELATED GENERA

Telephus has been variously classified by authors. Before the appearance of Hadding's work in 1913 the characters of the cephalon were not understood, so it seems unnecessary to cite views regarding the family relations of the genus prior to that date. However, in justice to Angelin it should be mentioned that for unstated reasons he classifies the genus as the type of a distinct family, Telephidae. Hadding, after a careful consideration of the relations of the genus to *Remopleurides* and *Cyclopyge*, (=*Aeglina Barrande*), the latter of which he regards the nearer to *Telephus*, concludes with the definite statement that " each of these genera must be maintained, each

genus represents a family." More recently Raymond[9] in proposing and defining the new family name Cyclopygidae instead of Aeglinidae Pictet—on the ground that *Aeglina*, which Barrande proposed in 1852 for his preoccupied term *Egle*, had in 1847 been given the name *Cyclopyge* by Corda—included *Telephus* as its third and last genus.

As the above heading indicates, I agree with Hadding and Angelin in viewing *Telephus* as representing a family that is quite distinct from both Remopleuridae and Cyclopygidae. Neither of those families seems to have any convincingly indicated relatives in pre-Ordovician faunas so far discovered. Still it has been rather generally assumed that the Remopleuridae are direct descendants of *Paradoxides*, and, as both are members of the Middle Atlantic fauna, I am inclined to admit their genetic relationship. However, Raymond, in the work just cited, suggests "that it is more probable that the proximate ancestor (of *Remopleurides*) is to be found in the Dikelocephalidae," a view that receives no support from my own work on the trilobites of the latter family. Among more probable progenitors of Remopleuridae, referring particularly to such rather aberrant members as *Robergia marginata* Raymond, *Apatocephalus* should be mentioned. As to the ancestors of *Cyclopyge* and its immediate allies, I do not recall that anyone has ventured a satisfactory opinion. In my estimation they still occupy unheralded ground. *Telephus*, on the other hand, does remind rather strongly of certain Upper Cambrian and early Ozarkian trilobites. I refer, namely, to *Irvingella* and *Chariocephalus*, two genera that have given us much trouble to classify but which I now find to agree well enough with *Telephus* in their cranidia, eyes, and other details of their free cheeks, and in their pygidia to convince me of the propriety of their reference to the Telephidae. The Cambrian and Ozarkian representatives of the family originated in the Arctic realm, but so far as known they left no record in subsequent invasions of North America from that source. Probably they became extinct there but continued their development through migrants to the middle Atlantic realm which supplied the faunas that at subsequent Ordovican times invaded epicontinental basins in eastern North America and Europe.

There are two other genera of trilobites in American Upper Chazyan deposits that seem to fit much better in the family Telephidae than in any other now established. One of these is *Glaphurus* Raymond, based on *Arionellus pustulatus* Walcott, 1880, from the reefy beds at the base of the Upper Chazy on Isle La Motte and elsewhere in the Champlain Valley. A close ally of this species occurs in the Whitesburg limestone in southwestern Virginia and at

[9] Raymond, Percy E., 1925, Bull. Mus. Comp. Zoölogy, vol. 67, No. 1, p. 64.

Pratts Ferry, Alabama. The other genus, for which the name *Glaphurina* is proposed, comprises a number of closely related species to one or more of which Raymond[10] applied the name *Glaphurus decipiens*. Raymond cites the occurrence of cranidia of this species, among them the holotypes from Bald Island, Mingan Islands, and adds that he "obtained a cranidium from the Lower Lenoir at Bluff City, Tenn., and another from the Holston limestone in the Catawba Valley, north of Salem, Va." If the latter two specimens are actually indistinguishable it is the only case of specific identity of Holston and Lenoir, not to say "Lower Lenoir," fossils known to me. I have two cranidia from the bed east of Bluff City that he calls "Lower Lenoir," but they are not strictly comparable with the figure of the holotype of Raymond's species. I have also a good cranidium from the Holston at Lexington, Va. But this also is not precisely like the holotype, nor is it the same as the much older Bluff City form. Finally, the collections before me comprise two cranidia of a *Glaphurina* from the reefy *Glaphurus pustulatus* bed at the base of the Upper Chazyan on Isle La Motte in Lake Champlain. But these specimens also are not quite like those from the Holston and the "Lower Lenoir," nor do they agree with Raymond's figure of the Mingan Islands holotype of *G. decipiens*. Apparently there are four distinguishable varieties or species of *Glaphurina*, and it does not help us much in working out problems of stratigraphic correlation to ignore the small differences that distinguish them.

Briefly stated and as shown by figures in Plates 7 and 8,[11] the proposed new genus *Glaphurina*, of which *Glaphurina lamottensis*, new species, is the selected genotype, is distinguished from *Glaphurus* mainly by absence of the convex band between the anterior side of the glabella and the anterior rim. In other words, the fixed cheeks in *Glaphurus* are connected by a broad similarly pustulated band between the glabella and the anterior rim, whereas in *Glaphurina* the glabella is separated from the rim only by a narrow furrow. Except that the eyes are much smaller and the free cheeks lack the long palpebral band, the general aspect of the cranidium of *Glaphurina* is practically the same as in *Telephus*. Although known only by cranidia it seems improbable that the family relationship of *Glaphurina* and *Glaphurus* will be questioned. Assuming this without further argument, the assignment of both to the Telephidae is rendered fairly reasonable by general agreement of the pygidium, thoracic segments, and free cheeks of *Glaphurus* with *Telephus*. Figures of these parts of *G. pustulatus*

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[10] Mus. Comp. Zoöl. Bull., vol. 67, No. 1, p. 1330, pl. 8, fig. 20, 1925.

[11] The writer had planned to discuss these genera in a separate paper, but time to write it is not at present available.

regarded as substantiating these claims are given in Plate 8. It may be noted that even the anterior spines of *Telephus* are suggested in *Glaphurus*, and that we are again reminded of that genus by the spines on the rim of the free cheeks.

Raymond places *Glaphurus* in the Odontopleuridae (Acidaspidae), but in my opinion this genus, and particularly Raymond's *Glaphurina decipiens*, which belongs to the group of species for which I am proposing the new genus *Glaphurina*, is closer to *Telephus* and possibly also to *Cybeloides* than to any of the true Odontopleuridae. In estimating the family relations of these genera I am inclined to place as much or more weight on their pygidial characters than on those of the cephalon. The pygidia of the first two indicate close relationship, but those of the encrinurid genus *Cybelopsis* and those of the Odontopleuridae suggest very distinct families, both of which are quite apart from the Telephidae. Doubtless many kinds of trilobites with intermediate structures existed, and some of these must be discovered before anything like a clear conception of the genetic relations of the Remopleuridae, Telephidae, Encrinuridae, and Odontopleuridae may be acquired.

The descriptions of the species of *Telephus* are followed by briefer statements concerning the genotype and hitherto only known and unquestionable species of *Glaphurus*, a new species of the same genus from the southern Appalachian region, and the four species that are now known of the proposed genus *Glaphurina*. Though perhaps inadequately described this can not be said of the illustrations. These are ample and true to nature, which after all are the most desirable qualities of a paleontological contribution.

NEED OF DISCRIMINATING SPECIES CLOSELY

That some may question the wisdom of dividing the "species" as closely as it is done in following pages is suggested by the relative looseness of conception indicated by specific identifications of species of *Telephus* in European publications. If complete specimens were always available the multiplicity of characters that go to make up each particular specific combination would render its discrimination and subsequent recognition much easier and more certain than with only cranidia on which to base conclusions. After all, it is not to be expected that striking differences should occur in the cranidia of closely allied species because conspicuous modifications of its characters commonly are of higher taxonomic significance. Striking modifications that are of more strictly specific importance, such, for instance, as in surface markings, do occur in the cranidium, but as a rule most of them pertain to the free cheeks, the thoracic segments, and the pygidium. In the free cheeks

variations in the size, form, position, and direction of the genal spines and in the size and form of the eyes and in the size of their facettes, also modifications in the outline of the pygidium and in the relative proportions of its lobes and segmentation may all be immediately notable and serviceable pecularities in comparing species whose cranidia are much less readily distinguishable. That there is abundant room for yet other easily distinguishable intermediate stages in the development of such parts appears when we compare the genal spines and eyes of *T. bicornis*, *T. mysticensis*, *T. bipunctatus*, *T. tellicoensis*, *T. mobergi*, *T. bicuspis*, and other species of which the free cheek is illustrated in this paper. That well-marked specific differences occur also in the pygidia is sufficiently indicated by comparison of these parts found with the cranidia of *T. mysticensis*, *T. fractus*, *T. bipunctatus*, *T. bicuspis*, *T. granulatus*, and other species. In short, it is highly probable and also in conformity with previous experience that if we had entire specimens even closer specific discriminations would be warranted. Moreover, experience is showing more and more clearly that if we are to get the utmost benefit from the fossils as stratigraphic and age indices it is absolutely essential to discriminate the species as closely as possible.

DESCRIPTION OF SPECIES

TELEPHUS FRACTUS Barrande

Plate 1, Figures 3–7

Telephus fractus Barrande, 1852, Syst. Sil. du centre Boheme, vol. 1, p. 891, pl. 18, figs. 30–34.
Trilobites expectatus Barrande, 1872, Suppl. vol. 1, p. 146, pl. 2, fig. 10.
Telephus fractus (Barrande) Hadding, 1913, Släktet Telephus Barrande, Meddelanden Lunds Geolog. Fältklubb, No. 18, p. 38, pl. 2, figs. 20–22. (Discusses species and republishes copies of Barrande's figures.)
Not *Telephus fractus* of other Authors.

Except Hadding's correction of previous views nothing has been added to our knowledge of this species beyond the information given by Barrande in 1852. Nor can I add anything except the statement of my conviction that as yet the species is confined to Bohemian localities. The Swedish form to which Angelin gave the name *T. wegelini* and which Tornquist subsequently referred to *T. fractus* was shown by Hadding to be distinct. Hadding also questioned Reed's identification of Barrande's species in the Whitehouse group of the Girvan District in Scotland, a doubt sufficiently warranted in my opinion to induce me to propose the new name *Telephus reedi* for the Girvan specimen. I agree with Hadding also in referring to *Telephus* the free cheek figured and described by Barrande in the supplement to his volume 1, under the name *Trilobites expectatus*,

and in believing that it belongs to this species. This cheek, judging from Barrande's figure of it, is very much like the one found in this country with *T. bicornis.*

As I have no specimens of *T. fractus* and have nothing to add to what has been published already the reader is referred to the works above cited for details not shown in the reproductions of Barrande's illustrations on Plate 1.

Occurrence.—Etage D 4, Lodewitz and Koenigshof, Bohemia.

TELEPHUS GRANULATUS Angelin

Plate 1, Figures 19–23; Plate 2, Figure 13

Telephus granulatus ANGELIN, 1854, Pal. Scandin., p. 91, pl. 41, fig. 21.

Bohemilla? denticulata LINNARSSON, 1875, En egendomlig Trilobitfauna från Jemtland, G. F. F. vol. 2, p. 291. (Free cheeks.)

Aeglina denticulata (cheek) and *Telephus bicuspis* (cranidia) HOLM, 1897, Palaeont. notiser, No. 4, G. F. F. vol. 19, pp. 461 and 463.

Telephus granulatus HADDING, 1913, Släktet Telephus Barr., Meddel. Lunds Geolog. Fältklubb, No. 18, p. 35, pl. 1, figs. 8–10

Though relying mainly on Hadding's work in estimating the characters of this species comparison of his figures of Swedish specimens referred by him to the species with Angelin's figure of the Norwegian specimen on which the latter founded the species gives no convincing reason for doubt as to their specific identity. Still, and aside from certain observed differences between Angelin's and Hadding's illustrations of the cranidium that can not be explained without direct comparison of the originals, I note also—in comparing Hadding's figures 8*a* and 9—differences in the shape of the glabella and in the outline of the free cheek that are not readily conceivable as due to compression and which therefore suggest confusion of two closely allied species or varieties rather than individual variation. The fact that both of these cranidia possess a pair of glabellar horns is not sufficient to prove the specific identiy of the animals to which they belonged. Such hornlike spines occur also in the clearly distinct American species, *T. bicornis*, the 40-plus cranidia of which afford convincing evidence of the constancy in cranidial characters that prevails in species of this genus. That the word "prevails" is not too strong is indicated by similarly manifested constancy in all other American species of which numerous specimens have been found.

Occurrence.—Angelin's type of the species is said to have been found in "D a?" in Norway. The specimens referred to the species by Hadding come from the upper part of the Ogygiocaris shale in Jämtland, Sweden.

TELEPHUS BICUSPIS Angelin

Plate 2, Figures 20, 21

Telephus bicuspis Angelin, 1854, Palaeontologia Scandinavica, p. 91, pl. 41, figs. 22, 22*a*.

Probably not *Telephus bicuspis* of Hadding.

My conception of this Norwegian species is based entirely on the figures given of it by Angelin and herein reproduced. Hadding identifies the species in Sweden and figures a number of cranidia from there under this name. But it seems almost impossible that Angelin[12] could have so poorely represented the characters of his species as appears on comparing his dorsal and anterior views of the cranidium with the corresponding views of the Swedish specimens that Hadding refers to the species and describes and figures, evidently accurately, in his work on the genus. The validity of this doubt is further indicated by the fact that Angelin's figures of the other two of his species (*T. granulatus* and *T. wegelini*) are far less discordant with the figures given of them in Hadding's paper than in the case of *T. bicuspis.*

Under the circumstances I have decided to reproduce Angelin's original figures of *T. bicuspis* without further comment and to propose other names provisionally for the Swedish specimens that Hadding referred to this species but which it seems to me are not only distinct from it but are themselves divisible into two species. Remarks concerning these follow.

Occurrence.—Angelin's type of the species came from some locality in northern Norway, probably near Mjosen where Holtedahl lists the species as a common fossil.

TELEPHUS HADDINGI, new species (provisional)

Plate 1, Figures 11–18

Telephus bicuspis (part), Hadding, 1913, Släktet Telephus Barrande, Geolog. Fören. Stockholm, vol. 35, p. 35, pl. 1, figs. 2–7.

Apparently not *Telephus bicuspis* Angelin.

My information concerning this proposed new species is based entirely on illustrations in Hadding's work of Swedish specimens referred by him to Angelin's Norwegian species, *T. bicuspis.* As mentioned in foregoing remarks on the latter, it seems highly improbable, not to say impossible, that the Swedish specimens figured by Hadding under that name are of the same species as Angelin's *T. bicuspis.* Both Angelin's and Hadding's illustrations are photographically reproduced on Plates 1 and 2 so that the reader may form his own conclusions regarding the specific relations of the concerned specimens.

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[12] Palaeontologia Scandianavica, pl. 41, figs. 22 and 22*a*.

I am further convinced that Hadding's Swedish specimens that he referred to *T. bicuspis* included cranidia of two distinct species. Three of those figured by him under that name belong to the form for which I propose the new name *T. haddingi*. The remaining fourth cranidium seems to represent a quite different species for which I propose the name *Telephus jamtlandicus*. Accordingly, I propose that the three cranidia represented by Hadding's Figures 2, 3, and 4, in Plate 1, be given the rank of cotypes of *T. haddingi*, whereas the original of Figures 1*a*, 1*b*, 1*c*, and 1*d*, in the same plate, should rank as the holotype of *T. jamtlandicus*.

Occurrence.—Lower part of the Ogygiocaris shale, Anderson, Jamtland, Sweden.

TELEPHUS JAMTLANDICUS, new species

Plate 1, Figures 8–10

Telephus bicuspis (part), HADDING, 1913, Släktet Telephus Barr., Geolog. Foren. Stockholm, vol. 35, p. 35, pl. 1, figs. 1*a*–1*d*, not 2–7, nor apparently *T. bicuspis* Angelin.

As mentioned previously it seems highly improbable that the cranidium represented by Figures 1*a*–1*d*, Plate 1, in Hadding's work on the genus is of the same species as the other specimens figured by him at the same time and in the same plate as *T. bicuspis*. The excepted cranidium is viewed as the holotype of the present species, the others being the basis for the proposed *T. haddingi*. The former differs from the latter in the shape of the glabella, this being wider and more bluntly truncate anteriorly and its lateral sides straighter than in the other. It differs from it also in lacking the low median ridge that is plainly indicated in both the dorsal and anterior views of all three of the cotypes of *T. haddingi*. Besides, the excavation between the two anterior denticles seems wider. In short, Hadding's figures of the two forms impress me as indicating two easily distinguishable species and leave the suggestion that *T. jamtlandicus* is really a closer relative of the Scottish *T. reedi* than of the associated *T. haddingi*.

Occurrence.—Same as the preceding.

TELEPHUS WEGELINI Angelin

Plate 2, Figures 10–12

Telephus wegelini ANGELIN, 1854, Palaeontologia Scandinavica, p. 91, pl. 41, fig. 23.

Telephus fractus TÖRNQUIST, 1884, Undersökningar öfver Siljansomradets Trilobitfauna, S. G. U., ser. C., No. 66, p. 89.

Telephus wegelini HADDING, 1913, Släktet Telephus Barr., p. 40, figs. 18, 19.

Angelin's figure and brief description of the cranidium of this species shows and mentions—probably in error—three closely approximated anterior spines. In other respects the figure agrees well enough with the figures of two other cranidia given by Hadding to warrant the belief that the latter are conspecific with Angelin's type of the species. Still it should be pointed out that the figures of the two cranidia used by Hadding show certain differences that are not all readily accounted for as due to distortion in the compression of the shale matrix. The relative shortness and the greater anterior width and bluntness of the glabella in Figure 19 as compared with Figure 18 is readily explained on that ground, as is also the difference in the relative sharpness of the antero-lateral angles. But I do not see why the anterior spines should be so much farther apart in Figure 19 than in Figure 18 if the same structures are shown in both. In fact I strongly incline to the belief that it is the inner pair that is shown in Figure 18 and only the outer pair in Figure 19.

Assuming that Hadding's Figure 18 represents something near the normal outline of the species it suggests *T. spiniferus* perhaps more than any of the other American species. In both the occipital spine is long and the surface tuberculated. However, the tubercles are smaller and more numerous in the Swedish species, and the figures give no indication of their longitudinal arrangement on the middle of the glabella nor of those on the fixed cheeks that are so strikingly indicated on the head of the American species. Besides, the free cheeks are narrower behind and wider in the middle in the latter and their outlines more rounded than in *T. wegelini.*

Occurrence.—Trinucleus shale, at localities in Dalarne, Sweden.

TELEPHUS MOBERGI Hadding

Plate 2, Figures 1–9

Telephus mobergi HADDING, 1913, Släktet Telephus Barr., Medd. Lunds Geolog. Faltklubb, No. 18, p. 37, pl. 2, figs. 12–17.

This doubtless is a good species and clearly distinguishable from previously described European species. It is also of unusual interest to me because its kinship to two or three of our American species is more obviously indicated than in any of the other instances. In one case, indeed, I am not sure that *T. troedssoni* Raymond, to which I am referring also some distorted American specimens from Alabama, can be distinguished satisfactorily from this Swedish species. The second American ally, of which many excellently preserved cranidia have been found and which seemed at first referable to *T. mobergi*, has proved on detailed comparison to differ too much in various respects from Hadding's illustrations of his species to permit using the same name for both. These differences are pointed out in re-

marks included in the description of *T. bipunctatus*, which is the name given to this second American relative of *T. mobergi.* The Swedish species is referred to also in the descriptions of *T. prattensis* and *T. transversus*, both of which, though more obviously different, I believe to be as near if not even closer allies of *T. mobergi* than is *T. bipunctatus*.

If Hadding's description of *T. mobergi* were in English it would be quoted here. But my acquaintance with the Swedish language is too limited to warrant an attempt to translate it, so the illustrations which are photographically reproduced here must suffice for the present.

Occurrence.—Lowest beds, (*Climacograptus putillus* zone), of the Ogygiocaris shale, Andersön, Jämtland, Sweden.

TELEPHUS LINNARSSONI, new species

Plate 2, Figures 15–17

Telephus wegelini Angelin, Warburg, 1925, Trilobites of the Leptaena limestone in Dalarne, p. 90, pl. 1, figs. 16–18.

This name is proposed for an imperfect cranidium supposedly collected by Linnarsson from the Leptaena limestone in Dalarne, Sweden, and which, according to Warburg, he evidently regarded as a new species and labeled *Telephus superstis.* Warburg,[13] however, was unwilling to accept Linnarsson's opinion, being persuaded that the observed differences between the Leptaena limestone specimen and those found in the underlying Black Trinucleus shale that are identified by Hadding and other authors with Angelin's *T. wegelini* are due mainly to distorting compression of the latter. To what extent Warburg's view of the systematic relations of the concerned specimens is warranted I am, of course, not prepared to say. But, assuming that the illustrations given by Hadding of typical *T. wegelini* and those of the Leptaena limestone specimen by Warburg are essentially correct, comparison of these brings out certain differences that after considerable experience in evaluating the effects of distortion of fossils by either vertical or lateral compression of the matrix seem to me unlikely to have been produced by such causes. For instance, the relative straightness of the anterior part of the outline, the protrusion of the two median denticles, the straightness of the posteriorly converging palpebral bands, and the truncate-conical rather than truncate-ovate outline of the glabella—all as seen in dorsal views of the cranidium of typical *T. wegelini*—could hardly have been produced by vertical compression of specimens precisely like that of the Leptaena limestone illustrated by Warburg. In the

[13] Trilobites of the Leptaena limestone in Dalarue, 1925, p. 90.

latter the anterior denticles are directed vertically downward, hence they do not show in a dorsal view; nor could they except the cranidium were so obliquely imbedded with respect to the bedding plane of the matrix that in the compression of the latter the length of cranidium—particularly the distance between the anterior margin of the glabella and the posterior edge of the occipital ring—would be greatly reduced. Nothing like this is indicated by comparison of the figures. On the contrary, the median thickness or width of the occipital ring in Warburg's figures of the Leptaena limestone specimen instead of being less, as it should be, than in Hadding's figures of supposedly typical specimens of *T. wegelini* is distinctly greater.

In view of these probable facts I am convinced that the Leptaena limestone specimen in question is not conspecific with *T. wegelini* and therefore propose to distinguish and name it as above in honor of the keen collector and observer who preceded me in recognizing its specific entity.

As I see it, the species that is as near as any to *T. linnarssoni* is the Bohemian genotype *T. fractus* Barrande. Warburg recognizes this relation but regards them as distinct. However, in pointing out the features in which they differ, that author mentions one that indicates comparison of typical *T. wegelini* with *T. fractus* rather than *T. linnarssoni*. In the latter the front and sides of the glabella are convexly curved throughout so that the sides even converge for a considerable distance posteriorly. In fact posterior rounding of the outline of the glabella is so unusual in species of the genus that it struck me at once; and it is particularly notable in comparing Warburg's figure of this cranidium with Hadding's figures of *T. wegelini*.

Warburg [14] having published a detailed description of the holotype of *T. linnarssoni* under the name *T. wegelini* in English it seems better to quote this than to attempt a description of my own:

> Cranidium about two thirds as long as wide. Axial furrows outside occipital ring very shallow, outside glabella deep and gently arched upwards, at first slightly, but gradually getting more strongly convergent; at the anterior margin of glabella they bend nearly straight inwards and somewhat downwards, and are united by the short, nearly straight, and considerable narrower preglabellar furrow. Glabella slightly more wide than long, oval, truncated at base, rather swollen, highest joint in front of occipital furrow, posteriorly slightly keeled, front part somewhat overhanging. On the sides of the glabella rather far forwards, there is a pair of very shallow, hardly discernible impressions recalling the more distinct impressions in some other species of this genus, as for example, *T. Mobergi* Hadding,[15] and *T. americanus* Billings.[16] Another slight impression is seen near the base of the glabella on one side,

[14] Trilobites of the Leptaena limestone in Dalarne, 1925, p. 90.
[15] 1913, Släktet Telephus Barr, Geolog. Foren. Stockholm, vol. 35, p. 37.
[16] Hadding, idem, 1913, p. 37, pl. 2, figs. 12–17.

on the other the test is not preserved at the corresponding place. Probably these impressions represent the glabellar furrows. Occipital furrow shallow, rather broad, not reaching axial furrows, its middle part slightly arched forwards, its lateral parts backwards. Occipital ring broad in the middle (from back to front), tapering towards the sides; convexity of anterior edge about the same as of posterior part of glabella, postero-lateral portions more strongly bent down and flattened, antero-lateral portions gently rounded; different portions separated by fine furrow, which disappears at base of median spine, which latter is broken off in this specimen. Glabella and occipital ring ornamented with sparse tubercles and net of very fine ridges, except at impressed places on glabella, in the anterior pair of which are a few rounded pits irregularly distributed. Doublure of occipital ring with fine transverse striae.

Fixed cheeks gently bent down, rather narrow, widest just behind front of glabella, gradually decreasing in width posteriorly to posterior margin; this continues far outside part in front, is rather strongly bent down and obliquely cut off by posterior branch of facial suture, which here takes a sharp turn outwards. Anterior margin of cheek directed somewhat backwards; antero-lateral angle rounded. Inner part of cheek rather flat in the middle, sloping down toward the margin. Inner anterior portion with net of ridges coarser than on glabella, a more strongly raised ridge along lateral and posterior margins. Palpebral lobe set off by clearly marked furrow, extending round anterior and lateral margins of inner part of cheek, flattened, slightly bent down at antero-lateral angle, rather broad in front, gradually tapering posteriorly. Anteriorly it continues underneath overhanging anterior portion of glabella along foremost part of dorsal furrow. Where this furrow meets preglabellar furrow (which here is the same as the anterior border furrow of cephalon, since there is no preglabellar field), the palpebral lobe bends steeply downwards, forming together with lateral part of narrow, more swollen, and strongly arched anterior border, the small anterior spines characteristic for this genus.

None of the American species is very closely allied to this youngest, apparently early Silurian, species. It suggests a cross between the *T. bipunctatus* and *T. fractus* groups, the general shape of the glabella and the obscure depressions on its lateral slopes reminding of the former, whereas the slight anterior overhang of the glabella and the abrupt downward direction of the median denticles are more in accord with the latter.

Occurrence.—Leptaena limestone, Boda, Dalarne, Sweden. Holotype in the Museum of the Geological Survey of Sweden.

TELEPHUS HIBERNICUS Reed

Plate 2, Figures 18, 19

Telephus hibernicus REED, 1909, Quart. Journ. Geol. Soc. London, vol. 65, p. 149, pl. 6, figs. 10 and 11.

Original description.—

Several small detached head-shields of a trilobite, with the peculiar characters of *Telephus*, occur in the crystalline reddish limestone (58) exposed west of Gortbunacullin Farm bridge. None are very well preserved; but, by piecing

together the evidence from the different specimens, the following description can be given.

Head-shield transverse, more than twice as wide as long. Glabella broadly semioval to subquadrate, nearly as wide as long, narrowing a little anteriorly, strongly convex, rounded in front. Occipital furrow slightly arched forward in the middle or straight; occipital segment simple. Axial furrows sharp, moderately strong, slightly convergent anteriorly. Cheeks much lower and less convex than the glabella, almost horizontally extended or slightly arched down on each side, of rounded or subtriangular shape, nearly as broad as long, surrounded by a flattened border, which broadens gradually to the middle, then decreases in width until it merges into the narrow anterior border in front of the glabella. Marginal furrow sharp, but not deeply impressed. Glabella and cheeks minutely tuberculated.

Dimensions.—Length=about 3 millimeters; width=about 6.5 millimeters.

Remarks.—This species seems almost indistinguishable from *T. bicuspis*, Angelin, but no pair of anterior spines has been observed in any of our specimens. The shape of the glabella, relatively wider cheeks, and absence of a median occipital spine distinguish it from *T. fractus*, Barr., which I have described [see *T. reedi*, n. sp., p. 19] from the Whitehouse Group in the Girvan district.

Judging from the quoted description and figures reproduced here in Plate 2, this species differs from all other Telephidae now known in the relative narrowness and parallel-sidedness of the glabella and the great median width of the fixed cheeks and nearly symmetrical curvature of their outer edges. The slight differences in these respects shown in Reed's figures of two cranidia may be accounted for by assuming that the original of his Figure 10 (reproduced here as fig. 18 in pl. 2) suffered some distortion by longitudinal compression, causing shortening of the glabella and cheeks and obtuse median angulation of the outline of the latter. Accordingly, I am inclined to regard his Figure 11 as probably a closer approximation to the undistorted original form of the cranidium. Reed probably is right in suggesting that his species is a close relative of the Norwegian *T. bicuspis* Angelin. However, this probable relationship is indicated much better by comparison with Angelin's figures of his species than with the figures of Swedish specimens referred to *T. bicuspis* by Hadding. The probability that Hadding misidentified Angelin's species is discussed on page 12.

Reed says that the anterior spines were not observed in his specimens. Most probably they are directed sharply downward as they are figured by Angelin in his *T. bicuspis* and as they do in *T. gelasinosus* and other American species of the typical section of the genus. In most of these cases delicate preparation of the specimens is required to reveal their presence, for even their bases are seldom shown in natural fracturing of the matrix.

Occurrence.—Tourmakeady Beds, near Tourmakeady, County Mayo, Ireland. According to a report on this district by Gardiner,

Reynalds, and Reed,[17] the Tourmakeady Beds are of Llandeilo age, which, however, is not very definite as regards the American sequence. Judging from the general aspect of the fauna listed from these beds, I am inclined to place them about the Middle or Upper Chazyan.

TELEPHUS REEDI, new species

Plate 1, Figure 1

Telephus fractus BARRANDE, Reed, 1903, Lower Paleozoic trilobites of the Girvan District, Paleontogr. Soc., p. 44, pl. 4, fig. 11.

This new name is proposed for the Girvan species of which incomplete cranidia were mentioned and one figured by Reed in 1903 and all referred by him to the Bohemian species *T. fractus* Barrande. Although the figured specimen is very imperfect and I have nothing better to base an opinion on than the figure given of it by the mentioned author, it yet seems impossible that it can be strictly the same species as *T. fractus.* Nor does it seem likely that it belongs to any of the Scandanavian species or to any of the American species herein described. Assuming that the figure is reasonably true to nature it must represent a species with an anteriorly extraordinarily truncated, subquadrate glabella that distinguishes it at once not only from *T. fractus* but also from all other species of the genus now known. Perhaps the nearest of the American species is my *T. spiniferus*, but comparison of the illustrations of the two forms on following plates can hardly fail to convince the observer that they are not even closely allied.

Compared with European species I note considerable resemblance to the similarly incomplete cranidium referred to *T. bicuspis* by Hadding and illustrated by Figures 1*a* and 1*b* in Plate 1 of his work on the genus. As figured the anterior end of the glabella of this specimen, which is provisionally distinguished on page 13 as *T. jamtlandicus*, is blunter—more truncate—and its lateral sides straighter than in the three other cranidia used by Hadding in illustrating the characters of this Swedish species. Nor does either the dorsal or the anterior view of it give any suggestion of the low ridge that is plainly indicated on the other figures as running longitudinally across the middle of the glabella. In all these respects this specimen makes a closer approximation to conditions found in the glabella of the holotype of *T. reedi.* Though it is believed that Hadding confused and included two distinguishable forms in the Swedish material referred by him to *T. bicuspis*, it seems certain that neither of them is strictly conspecific with the type of this Girvan species. The free cheeks in the latter are relatively too small and the curvature of their outer margins too sharp to justify identification in either case.

[17] Quart. Journ. Geol. Soc. London, vol. 65, pp. 104–154, 1909.

It is possible that the anterior truncation and overhang of the glabella of the Girvan type of this proposed new species was emphasized by pressure and oblique position of the cranidium with respect to the bedding plane of the matrix. But if this explanation of its present extraordinary appearance is correct it would at the same time imply uncommon original length of glabella. Under the circumstance I feel warranted, at least provisionally, in proposing the above new name for this Girvan species.

Occurrence.—Whitehouse group, Whitehouse Bay, Girvan District, Scotland.

TELEPHUS? SALTERI Reed

Plate 2, Figure 14.

Telephus salteri REED, 1914, Supplement Lower Paleozoic trilobites of Girvan, Paleontog. Soc., p. 16, pl. 2, fig. 11.

Original description.—

Specific Characters.—Head transversely elliptical. Glabella sub-cylindrical, slightly expanded at front end and projecting a little beyond cheeks, abruptly truncate, moderately convex, more than twice as long as wide at base; surface coarsely tuberculated. Axial furrows parallel for three-fourths length of glabella, diverging slightly at front end. Meso-occipital furrow distinct, marking off rounded smooth depressed meso-occipital ring, widest in middle. Cheeks rounded, nearly semi-elliptical, widest behind middle, rather wider than glabella, gently convex, with rather broad smooth flattened border extending round them and ending against glabella in front and at meso-occipital ring behind; marginal furrow strong; surface of cheeks granulated and with a few coarse tubercles on outer half.

Dimensions.—

Length of head-shield	3.6 mm.
Length of glabella	2.8 mm.
Width of head near base	5.4 mm.
Width of glabella at base	1.5 mm.
Width of cheek, (maximum)	2.1 mm.

Remarks.—There is only one specimen of this curious little trilobite available, but with the exception of the front end of the glabella it is well preserved. It is uncertain if a pair of anterior spines is present as in *T. bicuspis*, Ang., which it much resembles, though the cheeks in ours are relatively broader and more semi-elliptical and the glabella more cylindrical, and the neck-ring smooth and projecting behind the cheeks.

Judging from the description and figure of the holotype of this species it stands well apart from all others now known. Indeed, and particularly in view of the general sameness of the 20 or more other species of the genus, I doubt very much that its reference to *Telephus* is quite justifiable. The others in no case suggest that normal specific modification of the generic characters could produce the unheralded structural pecularities of *T. salteri.* Among the more striking of these is the relative narrowness of the glabella and, especially, its anterior expansion. Equally unexpected is the shape of the fixed

cheeks and the fact that the edge of the outer band, which should correspond to the palpebral band, departs fartherest from the dorsal furrow at the posterior lateral angles of the cranidium instead of in front. The anterior extension of the middle part of the head also is difficult to understand as a normal modification of the generic type. To say the least we require more information concerning this trilobite before it can be accepted as a properly classified and unquestionable species of *Telephus*.

Occurrence.—Balclatchie group, Balclatchie, Girvan District, Scotland.

TELEPHUS AMERICANUS Billings

Plate 2, Figures 22–27

Telephus americanus Billings, 1865, Pal. Foss. 1, Geol. Survey Canada, p. 291, fig. 281.

Telephus americanus Hadding, 1913, Släktet Telephus Barr., Geol. Fören. Förhandl., vol. 35, Häft 1, p. 4, text fig. 1*a*, *b*.

Original description.—

Glabella obtusely conical, length one-sixth greater than the width, rather strongly convex; front uniformly rounded; sides parallel; neck segment and furrow forming nearly one-third of the whole length; the furrow narrow and extending all across. The fixed cheeks are crescentiform, rounded on the outside, terminating posteriorly at the front edge of the neck furrow and extending around one-third of the width of the front of the glabella; an obscure groove just outside of the middle of the cheek, parallel with the margin in the front half, but running out to the edge before reaching the posterior corner. In front of the glabella there are two small projecting points. The surface is obscurely tubercular, and there is a small tubercle on the middle of the neck segment.

Length from two to three lines.

The detached glabellæ occur in considerable numbers, but I have seen none of the other parts in connection with any of them. There are no fragments that can be identified as belonging to this trilobite, except the glabella.

Through the kindness of Dr. E. M. Kindle, of the Geological Survey of Canada, I was given the opportunity of studying five cranidia used by Billings in describing this species. These were photographed, and plaster casts made of them are now in the United States National Museum. Three of the cranidia doubtless are strictly conspecific, the fourth also may be but requires more preparation before it will be fit for final classification. The fifth, which has a longer glabella, with straighter sides, a pair of faintly impressed pits, and smoother surface, may belong to a distinguishable variety or species. As these specimens show slight differences I propose that the one which bears the number 700*b* be selected as the holotype of the species. It is the best of the lot and most probably is the one figured by Billings and also the one of which the plaster cast was

made and mainly relied on by Hadding in preparing the drawings published by him.

The mainly distinctive features of the cranidium of *T. americanus* are the rather strong convexity and semiovate outline of the glabella, the small size and weak development of its surface tuberculation, the small anterior width and crescentic form of the fixed cheeks and the resulting general roundness of the lateral and anterior parts of the outline, and the relative narrowness of the occipital ring and the reduction of its spine to a minute elongate medially located node. Its nearest ally seems to be *T. mysticensis*, which, however, lacks the surface tuberculation, has somewhat wider and more crescent-shaped occipital ring, less evenly convex glabella, less sharply ridged fixed cheeks, and apparently more delicate anterior denticles. The nearest of the southern Appalachian species is *T. prattensis*, but the wavy and anastomosing longitudinal lines on its glabella and fixed cheeks, instead of pustules, render confusion in this case unlikely.

Occurrence.—Newfoundland, Division N and P, which probably locates the species stratigraphically somewhere within the span covered in the southern Appalachian region by the Blount group.

TELEPHUS MYSTICENSIS, new species and SIMULATOR, new variety

Plate 6, Figures 1–7

The surface of the glabella and fixed cheeks in both the typical form of the species and its variety seems entirely without tubercles, and if the occipital ring has a median tubercle or spine it must be very small. The shape and contour of the glabella is essentially as in *T. fractus* and *T. americanus* except that its middle third is flanked on each side by a shallow curved depression and the occipital ring is wider in the middle and more crescentic in outline. The outline of the sides and front of the cranidium in the holotype is rounded about as in *T. americanus*, but the part that lies in front of the middle third of the glabella is more prominent and distinctly incurved in front and the inner pair of the four frontal spines relatively small and so strongly curved downward that only the bases of these spines are visible in a dorsal view. The outer pair, however, is distinctly visible in such views. The fixed cheeks are as narrow as in *T. americanus*, but the convex area is longer, extending forward as a diminishing low ridge almost as far as the anterior extremity of the glabella. Excepting *T. americanus* the present species differs from all the other species of the genus in the approximately semicircular outline of its cranidium, in the general narrowness of its fixed cheeks, and in the fact that the convex areas of these cheeks are widest posteriorly instead of anteriorly and the outer pair

of the four anterior spines appear larger than the inner pair in dorsal view.

Comparisons with *T. granulatus* Angelin, founded on Swedish specimens, are given in preceding remarks on that species.

The larger of the two cranidia of this species now available, namely the one regarded as the holotype, shows some obscurely defined shallow depressions on the lateral slopes of the glabella. These suggest imperfectly developed glabellar furrows or dimples as occur in *T. bipunctatus* and *T. mobergi*. The second cranidium lacks these depressions and differs further from the holotype of the species in the more conical form of its glabella and in the greater width of the fixed cheeks. As it approaches *T. prattensis* in these respects it is provisionally distinguished as var. *simulator*.

Strangely, the preparation of our collections from Mystic revealed more than 10 free cheeks but only 2 cranidia and 2 pygidia. These cheeks are readily distinguishable from all others so far observed. The eyes, as usual, constitute by far the greater part of the cheek, but they are uncommonly bulbous and very finely facetted. Another peculiarity is that the thin rim carries no spine, only widening and the outline becoming obtusely angular at a point slightly behind the middle of the compound eye. Slight differences were noted in comparing these cheeks. In one set (figs. 3, 4), supposed to belong to the typical form of the species the eye is slightly longer, the rim wider and more sharply curved at the genal angle, and the anterior edge of the eye more distinctly overhangs the very thin anterior rim of the cheek than in the other set which is supposed to belong to the variety.

Two pygidia referred to this species agree in segmentation and general character fairly well with the pygidium ascribed to *T. fractus* by Barrande. However, they are longer and more quadrate or rather pentagonal than triangular and terminate posteriorly in a sharp angle or short spine and show a pair of still blunter projections at points nearly midway between the median posterior spine and the antero-lateral angles.

Occurrence.—From a highly fossiliferous limestone boulder supposed to be of Blount, or at least Chazyon, age in the conglomerate near Mystic, in the southwestern corner of the Province of Quebec.

Holotypes of species and variety.—Cat. Nos. 80526, 80527, U.S.N.M.

TELEPHUS BICORNIS, new species

Plate 4, Figures 1-14

As shown by the illustrations the cranidium of this species agrees rather closely in all save one conspicuous feature with the cranidia of *T. pustulatus*, *T. gelasinosus*, and one or two others of the numerous American species here described. The distinctive character re-

ferred to and which suggested the species name *bicornis* is the presence of a pair of long and rather slender spines or horns at the top or beginning of the frontal slope of the glabella. These spines project obliquely forward, outward, and upward and have a length approximately equaling half the width of the glabella. The surface is pustulated and the occipital spine well developed as in the mentioned species. The fixed cheeks differ slightly from those of *T. pustulatus* in their outlines and more particularly in being decidedly narrower. The eyes, as usual, are very large and, disregarding the genal spines, make up much the greater part of the free cheeks. The height or width of the visual surface is to its length about as one to three. In the middle third of the eye of an adult specimen about 23 facets occur in each of the diagonally intersecting rows. The outer rim of the cheek is narrow and prolonged at its widest point into a long, straight, compressed, and obliquely striated genal spine. The base of the latter lies somewhat behind the middle of the eye, projects almost directly outward and attains a length slightly exceeding that of the eye. The pygidium is obtusely triangular in outline, its axis wide and high, clearly outlined, and crossed by three double rings, each of which carries a pair of strong spinelike knots in its middle third, some small tubercles outside of these, and a low swelling at each end. The pleural lobes are narrow, the outer half broadly concave, the inner half rising into a low ridge on which two segments are obscurely indicated.

Whereas the striking glabellar spines serve very satisfactorily in distinguishing *T. bicornis* from all the other American species of the genus and also from all but one of the European species, their value as a distinguishing character fails when we compare it with the similarly bicornute Swedish species to which Angelin applied the name *Telephus granulatus*, especially as that species is illustrated by Hadding. Indeed, when I first saw the latter's figures of *T. granulatus* I welcomed them as probably giving the first valid grounds for the identification of an American species of *Telephus* with an European one. This relation was suggested particularly by the smaller cranidium shown in his Plate 1, Figure 9, which differs from the larger, apparently more typical, example of the species shown in Figures 8*a*, *b*, *c*, in the straighter anterior outline of the cranidium and the more conical and anteriorly more narrowly rounded glabella. In both respects this smaller cranidium makes a closer approach to the cranidium of *T. bicornis* than does the larger specimen. Possibly the noted differences are due to distortion by rock compression or to differences in posing. Whatever the reason may be, whether structural or fortuitous, careful comparison with the published figures of the Scandinavian species, including the one given by Angelin, leaves no doubt as to the distinctness of the American bicornute

species. Some 40 cranidia of the latter, while indicating extraordinary agreement among themselves, differ constantly from the figures of Norwegian and Swedish specimens referred to the former in (1) the greater width, contour, and shape of the fixed cheek; (2) in the inferior length, more regularly semielliptical outline, and greater median convexity of the glabella; (3) in the greater separation and less anterior position of the bases of the glabellar spines; and (4) the presence of tubercles on the outer parts of the fixed cheeks and the wider distribution of the tubercles on the glabella and also on the occipital ring. Other less conspicuous differences will be observed in comparing figures of the two species; the occipital spine, for instance, seems to be stronger, whereas the ridge on the free cheeks is not so sharp as indicated in Hadding's illustrations.

Comparison of their respective pygidia discloses equally distinctive peculiarities. Hadding's illustration of this plate in *T. granulatus* shows two axial rings behind the anterior half ring, each of the two with a single median tubercle or short spine and without other tubercles. In *T. bicornis*, on the other hand, a narrow tuberculated third ring makes the posterior extremity of the axis, and each of the two rings in front of it carries a pair of spines and besides these one or two rows of tubercles between them and the dorsal furrows.

The free cheeks, except for the large bulbous and beautifully faceted eyes, are very narrow. Except at the genal angle only a narrow smooth rim follows the outline of the eye. The genal spine begins with a broadly swollen and outwardly rapidly tapering base, its further extension being very long and slender, only slightly curved, and obliquely striated. A much shorter spine lies just behind it.

Only two thoracic segments were found, and both consisted only of the axial part. Though similarly covered with tubercles, one carried the expected pair of median spines, but the other (see pl. 4, fig. 14) had only one and this in the middle of the axis. The pleural parts are short and apparently terminate bluntly.

Because of the two glabellar horns it is not likely that reasonably complete cranidia of this species will be confused with any of the other species here described. A like statement regarding the free cheeks and pygidia would scarcely be warranted because we know these parts of only a few of the species. But they are surely quite distinct from the few other kinds of *Telephus* free cheeks and pygidia that have been discovered. That those referred to *T. bicornis* actually belong to this species is rendered fairly certain by the fact that whereas cranidia were abundant in a thin layer at the type locality no other species of the genus was found either with them or in any other bed at this place.

Occurrence.—Whitesburg limestone, John Grayson's farm, about 4 miles southwest of Bland, Va.

Cotypes.—Cat. No. 80535, U.S.N.M.

TELEPHUS GELASINOSUS Ulrich

Plate 7, Figures 12–14

Telephus gelasinosa (Ulrich) BUTTS, 1926, Geology of Alabama, pl. 19, figs. 1, 2.

This species is characterized by the combination of a relatively long glabella, rather narrow strongly convex free cheeks, somewhat rounded anterior outline, pustulose surface, and strong, sharply deflected anterior spines. The glabella is strongly convex along its middle with distinctly flattened lateral slopes, truncated conical, the maximum length and width about equal. The posterior lobes are outlined by a small inwardly diminishing ridge instead of a furrow. Unfortunately both specimens on which the species is founded lack the posterior edge of the occipital ring, so it is impossible to say anything concerning the character of the occipital spine that probably occurs on more perfect specimens.

Compared with other American species of the genus, *T. gelasinosus* is at once distinguished by its relatively longer glabella. It is approached in this respect, also in the size, outline and contour of the fixed cheeks, by *T. granulatus* Angelin but differs conspicuously in the shape of the glabella, which is distinctly conical instead of subquadrate. It lacks also the two horns on the anterior slope of the glabella that set *T. granulatus* and *T. bicornis* apart from all the other species of the genus. The present species reminds also of *T. latus* but has a longer and more convex glabella, more sharply deflected anterior spines, and, particularly, narrower and more strongly convex fixed cheeks. In the two remaining pustulose species, namely, *T. pustulatus* and *T. fractus* Barrande, the glabella is much shorter and semiovate rather than conical.

Occurrence.—From a subgranular limestone containing *T. bipunctatus* in abundance, at Pratts Ferry, Ala. This bed of limestone lies between the base of the graptolite-bearing Athens shale and the top of the Lenoir limestone, hence its position corroborates the evidence of its fossils on which mainly it is correlated with the Whitesburg limestone of Tennessee and Virginia.

TELEPHUS LATUS, new species

Plate 3, Figures 13, 14

This species is based on two cranidia. These agree in size with *T. fractus*, the Bohemian genotype, but are considerably larger

than any of the other American species. The outstanding structural characteristic lies in the form and size of the fixed cheeks. The outline of these is more regularly curved and their convex areas broader and more flatly convex than in any other species of the genus. On the other hand, the outer pair of the frontal spines is uncommonly weak, being reduced, as in *T. fractus*, to mere angulations of the thickened rim. The occipital ring is only moderately wide and the neck spine exceedingly short and directed backward. Just in front of the latter is a distinct rounded node that may represent the "median eye" of *Isotelus* and many other trilobites. A minute body similar to that described by Ruedemann as the lens of this probable eye was observed in preparing the specimens.

The convexity of the glabella is less than in specimens of most of the other species of the genus, but this inferiority is regarded as due in small part to reduction in rock mass by pressure subsequent to fossilization. As in *T. fractus* and other species the convexity of the glabella is greatest in the middle, the convexity of the lateral slopes being appreciably lessened so as to produce an obscurely defined median ridge. The entire surface of the glabella is loosely covered with low tubercles that seem to be more plainly indicated on the cast of the interior than on the outer surface of the test. Similarly arranged but even lower pustules occur on the anterior half of the gently convex areas of the fixed cheeks. A low ridge crowned with a row of tubercles defines the outer limits of the convex areas and assists in deepening the palpebral furrow.

In general aspect *T. latus* reminds considerably of Angelin's *T. granulatus* but is clearly distinct, attaining nearly twice the size of that species and having a more conical glabella and wider as well as less convex fixed cheeks. It also lacks the two large nodes or spines on the anterior slope of the glabella and has a shorter occipital spine.

Occurrence.—This species has been found only in the limy basal part of the Athens shale at the north end of the old limestone quarry, nearly 3 miles southeast of Saltville, Va. Here it is associated with *Telephus spiniferus*, *Robergia major* Raymond, *Ampyxina powelli* Raymond, and various species of graptolites, including *Nemagraptus gracilis* Hall. Although seemingly occupying the position of the Whitesburg limestone, the fauna consists practically entirely of Athens shale species and not of Whitesburg limestone fossils. Evidently the zone of *Robergia major* belongs to the Athens and not in the older Whitesburg formation.

Holotype.—Cat. No. 80539, U.S.N.M.

TELEPHUS PUSTULATUS, new species

Plate 3, Figures 1–10

The cranidium of this species reminds in many respects of *T. latus*, having like it a very short spine projecting from the middle of the posterior edge of the rather narrow occipital ring and in front of this a conical elevation, wide and only moderately convex fixed cheeks and similarly placed pustules on the glabella, occipital ring and fixed cheeks. However, *T. pustulatus* differs from the Saltville species in the greater convexity of the glabella and fixed cheeks, more strongly developed surface pustules, and in the shape and dimensions of the glabella, this being shorter, less conical in lateral outline, and more rounded in anterior outline than in *T. latus*. Further, the greatest width of the cranidium is proportionately greater by a third mainly because of the relative shortness of the glabella. Finally, all the furrows are deeper, the outline of the fixed cheek is less regularly rounded, making the anterior outline of the cranidium straighter and the anterior spines turn downward more rapidly than in the larger species.

As usual the free cheek consists mainly of the great eye. This is sharply separated by a deep groove from the narrow outer rim. The latter widens slowly backward to attain its greatest width at the base of the genal spine. The latter, contrary to expectations, does not extend outwards but rises erect from the top surface of the rim and in such manner that its lower part is in contact with the facetted part of the eye.

The pygidium consists mainly of the axis, the pleural lobes being narrow and comprising little else than a concave border. The axis is rather broadly triangular, has three, or it may be only two, rings, the first and especially the second being rather wide and flat-topped and separated by deep grooves, the third much smaller and thinner and close to and probably merging with the posterior rim of the pygidium. Each of the rings carries a low node on its postlateral angles, the second shows the broken base of an antero-median spine whereas the first shows the base of a more centrally located spine with three or four small tubercles on each side of it. The dorsal furrows are shallow, and outside of them the convex parts of the pleural lobes make very narrow low ridges that merge with the sides of the second axial ring.

Compared with European species only *T. fractus* Barrande appears on first sight much like *T. pustulatus*. However, this resemblance rests mainly on the similarity in their respective glabellas, detailed comparison showing more or less clearly recognizable difference in all other parts.

Occurrence.—The types were found in the Whitesburg limestone at Lexington, Va. With them occurred a specimen agreeing in all respects except the glabella, which is a trifle longer. Another cranidium was found in the same formation near Albany, Tenn. The latter being somewhat distorted by pressure I could not decide whether its structure is more like that of the types of the species or like the second variety.

Holotypes and paratypes.—Cat. No. 80536, U.S.N.M.

TELEPHUS SPINIFERUS, new species

Plate 3, Figure 11

The holotype of this species—a rather well-preserved cranidium—has only about half the width from palpebral edge to palpebral edge as do the specimens of *T. latus* with which it was found. If differs also very decidedly when details of structure are compared. In the first place, whereas *T. latus* has a very short occipital spine the corresponding spine on *T. spiniferus* is stronger and much longer, its length being nearly equal to that of the glabella in front of the occipital furrow. Next, the fixed cheeks are wider in front and extend forward beyond the anterior extremity of the glabella. In consequence the anterior outline of the cranidium is different, being slightly but definitely concave in its inner three-fifths and the whole anterior and lateral parts of the outline much less convexly bowed. The antero-lateral outline of the convex areas of the fixed cheeks and also of the palpebral bands is more sharply curved. Third, the convexity of the whole and particularly of the glabella is relatively less in *T. spiniferus* even when the slight vertical compression of the specimens is taken into account. Finally, the tubercles of the surface of the glabella and over the anterior half or more of the convex areas of the fixed cheeks though smaller are more distinct and more numerous, and those on the middle half of the glabella exhibit a more regular arrangement in anteriorly slightly diverging rows.

The unusual length of the occipital spine and the longitudinal arrangement of the surface tubercles on the middle of the glabella will distinguish this species at once from most if not all others of the genus. A long spine occurs also in one of the varieties of *T. bipunctatus* and in other species—notably in *T. troedssoni* and *T. buttsi*—but in all these cases the differences in other respects are too conspicuous to be likely to cause confusion.

Occurrence.—The holotype was found in association with *Telephus latus*, *Robergia major* Raymond, and graptolites of several species in the limy basal part of the Athens shale overlying Holston limestone in the large quarry 3 miles southeast of Saltville, Va.

Holotype.—Cat. No. 80537, U. S. N. M.

TELEPHUS SPINIFEROUS CALHOUNENSIS, new variety

Plate 3, Figure 12

This name is proposed provisionally for a single cranidium that has lost its posterior part but retains its anterior and middle parts in reasonably good condition. What remains of it recalls *T. spiniferus* rather more than any of the other species known to me. On this account and pending discovery of information respecting the specifically important occipital ring and spine present purposes are sufficiently served by classifying it as a variety of this species. At least two peculiarities warrant its separation from typical *T. spiniferus* and even suggest that a complete head would demonstrate quite as close relations to such other species as *T. mobergi*, *T. Sinuatus*, and *T. bilunatus.* In fact, I am satisfied that when such specimens are discovered they will give ample grounds for the promotion of the variety to the rank of a distinct species. At present, however, we are mainly concerned with the features that distinguish it from typical *T. spiniferus.* The first of these, as the reader will observe in comparing their dorsal views in Plate 3, lies in the outline of the gabella, which diverges more rapidly backward, then curves inward before reaching the occipital furrow and gives a greater width to the posterior fourth of the glabella in the variety than in the older typical form of the species. The second difference pertains to the presence of shallow curved furrows in the posterior two-thirds of the glabella in the variety and their absence in the holotype of the typical form of *T. spiniferus.*

Occurrence.—Seventy-five feet beneath the top of the Athens shale, bluff on north side of Hiwassee River, 1½ miles east of Calhoun, Tenn.

Holotype.—Cat. No. 80538, U.S.N.M.

TELEPHUS SINUATUS, new species

Plate 3, Figure 15

A single cranidium from the Whitesburg limestone at Lexington, Va., reminds in its occipital spine and in the outline and moderate convexity of the glabella of *T. spiniferus.* Possibly it represents a near progenitor of that species, but certain of its features differ so obviously from the corresponding parts of *T. spiniferus* that it seems unwise to refer the Lexington specimen to the same species. Although recognizing the possibility that future collections may bridge the distinctions now so strikingly displayed, the chances that the required intermediate stages may be found are thought to be too remote to warrant ignoring structural differences that if recognized

as separating closely allied but distinguishable forms will add one more to the list of useful guide fossils. Besides, it is thought even likely that the form which it is proposed to call *Telephus sinuatus* is really more closely allied to *T. bipunctatus* and *T. mysticensis* than *T. spiniferus.*

The occipital spine in the holotype of *T. sinuatus* is broken, but enough remains to indicate a length and direction similar to that of the corresponding spine in *T. spiniferus.* As said the outline and convexity of the glabella also is not strikingly different except in its posterior part. Namely, the anterior side of the neck furrow is not straight as usually is the case in species of *Telephus* but curves backward on either side of the middle third, the undulations being due to the imperfect development of a pair of posterior glabellar lobes. The neck furrow therefore is curved in a manner simulating a "Cupid's bow." Other more obscure marks in the slopes of the glabella and which doubtless are related to glabellar furrows are shown in the illustrations in Plate 3, but, as will be observed, there is nothing like the distinct pair of dimples which are so characteristic of *T. bipunctatus.* In fact, although clearly outlined the middle part of the spots is slightly raised instead of deeply impressed.

In the anterior and lateral parts of the outline of the cranidium and in the shape and size of the fixed cheeks *T. sinuatus* agrees much better with *T. mysticensis* and *T. gelasinosus* than with either *T. spiniferus* or *T. bipunctatus*, the general outline being more rounded and the fixed cheeks smaller than in the latter two species.

Occurrence.—The holotype and only known specimen was found in the Whitesburg limestone at Lexington, Va. The Whitesburg in the vicinity of Lexington is very fossiliferous. After years of collecting the total fauna from this bed and place comprises more than 80 species, 30 of them trilobites.

Holotype.—Cat. No. 80540, U.S.N.M.

TELEPHUS BIPUNCTATUS, new species

Plate 5, Figures 1–9

This is by far the most abundant and most widely distributed of the American species of *Telephus.* It is very constant in its characters and perhaps also the best marked. In view of the excellent, and in every respect sufficient, illustrations given on Plate 5 it seems unnecessary to supplement these with a detailed description. However, the more desirable comparisons with other species should not be omitted.

Compared with previously described species only one is at all closely allied to *T. bipunctatus.* This is the Swedish *T. mobergi* Hadding, which also has depressions or pits in the lateral slopes

of the glabella, a small occipital spine, lineate surface markings, the antero-lateral parts of the fixed cheeks subangular and their convex areas pinched into a curved ridge. However, the glabella is not so convex as in our species and relatively not so broad. Besides, the pits on either slope are shallower, not so widely separated, and extended both forward and backward into characteristic long shallow sigmoidally curved furrows that are wanting in the American species. In the latter, on the contrary, the posterior glabellar lobes are outlined in a manner wholly lacking in Hadding's figures of *T. mobergi.* Then, taken as a whole, the length of the cranidium in *T. bipunctatus* is decidedly less than in its Swedish ally, the anterior spines are farther apart and distinctly separated from the adjacent slightly produced angles of the frontal rim, the anastomosing surface ribbing extends over the anterior halves of the fixed cheeks and the anterior as well as the posterior parts of the glabella, and the fixed cheeks, including the palpebral bands, are wider in front and more distinctly triangular in outline.

Compared with American species there are at least four that must be counted as closely related to *T. bipunctatus.* These allies include *T. impunctatus*, *T. prattensis*, *T. tellicoensis*, and *T. hircinus.* The distinctive features of each are given under their respective headings.

The pygidium that is referred to this species is small, triangular in outline, very convex, with very narrow concave pleural lobes and correspondingly large axis. The first ring of the latter carries two small spines near the middle, the second apparently a single though probably a double headed larger node, the third, or terminal ring, which is small and not deeply separated from the second, has a node on each end.

The free cheeks so far discovered with cranidia of this species are all more or less imperfect. The rim is narrow even at the base of the genal spine, of which usually only the stump remains. However, it is retained on the specimen from Lexington, Va., and its strongly curved character, length, and weak base together probably explain its loss in the other specimens. The eyes are large but not so bulbous as in the associated *T. pustulatus*, and the ocular facettes are rather small but not minute as in *T. mysticensis.* They are larger also than in *T. pustulatus.*

Occurrence.—Over 50 specimens of the cranidium of this species were collected from the Whitesburg limestone—a 20 to 40-foot zone of dark gray, irregularly bedded subcrystalline limestone between the Holston marble and Liberty Hall limestone—at Lexington, Va. Only a single pygidium and only one free cheek were observed at this locality. Cranidia occur equally abundant in the corresponding limestone at localities in the vicinity of Albany, Tenn. At these

places a half dozen or so of pygidia—five of them like the one at Lexington, Va.—and one or two imperfect free cheeks were found with the cranidia. Fewer specimens have been found at other Appalachian localities, the most southern being at Pratts Ferry, in central Alabama, in every case in a thin bed of subcrystalline limestone at the base of or rather just beneath the Athens shale.

Cotypes.—Cat. No. 80543, U.S.N.M.

TELEPHUS IMPUNCTATUS, new species

Plate 5, Figures 10–15

This species is based on a number of cranidia that suggest more or less close relations to *T. bipunctatus*, *T. prattensis*, and *T. tellicoensis* without being in any case sufficiently like one or another of the mentioned forms to warrant identification. The general outline of the cranidium is most like that of *T. bipunctatus* from which it is immediately distinguished by the absence of the deep pair of glabellar pits. The glabella is also relatively not so wide posteriorly and its sides less curved, its outline therefore being more conical than in that species. In one of the cranidia referred here (see pl. 5, fig. 13), very shallow and small glabellar pits occur that remind one of *T. bipunctatus.* The proportions of this specimen also differ somewhat from the others, the cranidium being relatively longer. Finally, in all of the specimens that preserve the occipital spine it is stronger than in *T. bipunctatus.*

In general aspect these cranidia remind rather more of *T. prattensis* than of *T. bipunctatus.* In fact the glabella is practically the same as in that species. However, the occipital spine is larger and the fixed cheeks, being wider in front and the outline consequently more sharply recurved, are notably different. In these respects *T. impunctatus* is not much unlike *T. tellicoensis.* The resemblance in this case is heightened by the strength of the occipital spine. But the cheeks are not quite as wide as in that much younger species nor is the occipital spine as strong or directed so much upward, whereas the glabella is distinctly longer than in the Tellioco species.

Though the cranidia that I refer to this species in a few instances are not very sharply distinguished from those of the species with which they have been compared the case is quite different with respect to the pygidium that was found with them. Though built on much the same plan it is much wider, both as regards the axis and the pleural lobes, and also less convex than are the pygidia found with and assigned to *T. bipunctatus*, *T. hircinus*, and *T. tellicoensis.* As usual the anterior half of the first axial ring carries a pair of small median spines, and the second shows the stump of a single

much larger spine. Unfortunately the posterior extremity of the pygidium is missing, so that its characters remain unknown. The uncommonly wide pleural lobes are covered with very fine striae paralleling the outer edge.

Occurrence.—Whitesburg limestone, near Albany, Tennessee, where it is associated with more numerous specimens of *T. bipunctatus.* Also at Pratts Ferry, Alabama.

Cotypes.—Cat. No. 80544, U.S.N.M.

TELEPHUS PRATTENSIS, new species

Plate 3, Figures 16–19

Associated with typical specimens of *T. bipunctatus* a single small but good cranidium was found in 1910 at Pratts Ferry, Alabama, that departs in important respects from the usual characters of that species. Since then three other but structurally precisely similar cranidia were found in the lower 50 feet of the typical section of the Whitesburg limestone in Tennessee. In certain of their features these specimens approach the three Tellico sandstone species of the genus without, however, agreeing exactly with any of them. For convenience of reference it is thought advisable to give them another name, leaving to the future the decision as to its final and true systematic position.

Compared with *T. bipunctatus* it is distinguished at once by the very slight depth or complete obsolescence of the glabellar pits and absence of any indication of the posterior pair of lobes. Otherwise the glabella is nearly the same as in *T. bipunctatus*, particularly in the matters of outline and general convexity. Comparing other features, however, it is found that the lateral parts of the palpebral band are wider whereas the anterior spines are relatively smaller and less widely separated, the antero-lateral parts of the outline of the cranidium are more rounded, the convex areas of the fixed cheeks are smaller and much narrower anteriorly, and the occipital furrow straighter than in *T. bipunctatus.* These differences impart an aspect to the cranidium sufficiently distinctive to convince one that entire specimens of these trilobites would show equally important peculiarities in the unknown parts.

A closer relative perhaps is *T. impunctatus*, in which the glabella may be said to be precisely similar in form and surface markings. The present species, however, has a much smaller occipital spine, the anterior part of the outline of the cranidium more rounded, and the fixed cheeks decidedly smaller. The last character distinguishes *T. prattensis* from all of the Whitesburg and Tellico species.

As said, *T. prattensis* suggests relations to the Tellico species *T. hircinus*, *T. tellicoensis*, and *T. transversus*, in all of which the glabellar pits tend to partial or complete obsolescence and the anterior rim is relatively wide. However, on further and more critical comparison it differs from all of them in being smaller and in having much smaller fixed cheeks; and from the first in the greatly inferior development of the anterior and occipital spines; from the second in its relatively longer cranidium and glabella and anteriorly narrower and outwardly more rounded (less triangular) fixed cheeks; and from the third in its longer cranidium and glabella, more convex glabella, smaller anterior spines, and smaller as well as more definitely ridged and differently outlined cheeks. The anterior edge also seems to be more arched in anterior view and is decidedly more rounded in outline in dorsal views.

None of the other species is as near in cranidial characters as those mentioned in the above comparisons nor close enough to require further comment. A possible exception would be *T. mysticensis*, in which the fixed cheeks are still narrower, especially anteriorly, and the cranidium as a whole relatively longer and more rounded in outline anteriorly.

Occurrence.—Found with *T. bipunctatus* in a thin bed of subcrystalline limestone regarded as representing the Whitesburg limestone. This bed lies between the base of shaly and argillaceous graptolite bearing limestones referred to the Athens shale and the top of massive beds of Lenoir limestone at Pratts Ferry, Ala. Other specimens from the lower 50 feet of the Whitesburg limestone, about 1.5 miles southeast of Whitesburg and 2 miles southwest of Bulls Gap, Tenn.

Cotypes.—Cat. Nos. 80541, 80542, U.S.N.M.

TELEPHUS TELLICOENSIS, new species

Plate 6, Figures 10–19; Plate 7, Figures 10, 11

The available material of this species affords the nearest approach to a conception of the complete carapace of *Telephus*. The specimens occur in a hard matrix tenaciously adhering to the test. Out of over 50 cranidia about half were prepared for study and found to conform strictly to type. The rock contained also many free cheeks, fewer pygidia, and yet fewer and generally broken thoracic segments.

The cranidium agrees in general and especially in the outline of the glabella and surface markings with *T. bipunctatus* but lacks entirely the pits and other markings indicating glabellar furrows. Further comparisons show among other differences that the occipital spine is much larger, the fixed cheeks somewhat narrower and their

outer edges more nearly longitudinal in direction. Though readily distinguished, it yet appears entirely probable that *T. tellicoensis* is a well modified descendant of *T. bipunctatus*, which is a common fossil in the Whitesburg limestone and, so far as known, confined to it.

The cranidium might be compared with those of various other species, notably *T. hircinus*, *T. mobergi*, and *T. prattensis*, in all of which the surface shows raised and more or less anastomosing lines that are characteristic of the *T. bipunctatus* section of the genus. However, it hardly seems worth while to say more than that none of the mentioned species is quite like the present.

The free cheeks are remarkable for two reasons; first, the great size and relatively coarse facetting of the eyes and, second, the invariable presence of two large diverging spines, both springing from the outer side of the narrow rim, one at a point near the middle of the length of the eye, the other a short distance behind it. The eye facets are arranged, as usual, in quincunx, making diagonally intersecting and transverse rows with 13 or 14 of the latter sufficing to cover the highest part. The outer rim is sharply separated from the eye by a deep groove, very narrow in front, wider behind, and widest in the middle third which bears the two large spines. The two figured free cheeks show considerable difference in the form and width of the spine-bearing part, and it is quite possible that the larger of the two belongs to another species—perhaps to *T. hircinus*.

Two very slightly differing kinds of pygidia were found with the foregoing cranidia and free cheeks. They differ mainly in one being relatively shorter or wider than the other. Most of the greater width of the former is added to the concave and yet very narrow and obscurely defined pleural areas and border. Both kinds have a small triangular flat posterior spine, but this is a little shorter in the wider form, and the edge of the pygidium turns laterally from the spine more abruptly than in the narrower kind. In consequence the outline of the pygidium as a whole is more regularly triangular in the narrower form than in the wider one. Specimens of the cranidium of *T. tellicoensis* being much more abundant in the rock than are the parts of associated species, it is thought likely that its pygidia also would occur oftener. Hence, the narrower kind, of which eight specimens were found whereas only two examples of the wider form were observed, is referred to this species. The other may belong to either *T. hircinus* or *T. transversus*, with the probabilities favoring the former.

Only six or seven kinds of pygidia referable to species of this genus have been detected in American deposits. The first of these occurred with the cranidia of *T. mysticensis*. It has three blunt marginal spines, two of them merely sharp angles, and three axial segments, the anterior of which carries a single low median node. The second

is referred to *T. bipunctatus.* It is slightly wider than the others, seems spineless behind, has but two axial segments, the anterior of which carries two small nodes or short spines whereas the broad posterior one rises apparently into a single larger spine. The third, referred to *T. impunctatus*, is less convex, wider in front (more broadly triangular), and has wider pleural lobes than the others. The fourth, which is doubtfully referred to *T. troedssoni*, probably the nearest American relative of *T. mobergi*, is much like the third in outline, with, respectively, two and one nodes on the anterior and posterior axial rings. The two slightly different pygidia found with *T. tellicoensis* and *T. hircinus* have a posterior spine and two axial segments, with two small nodes on the anterior segment and one, or it may be two, larger ones on the posterior one.

Occurrence.—Tellico formation associated with *T. transversus* in a bed of reddish crystalline limestone 10 feet above the base of the Tellico formation, one and one-half miles southeast of the Southern Railway station in Knoxville, Tenn. In this belt the Tellico rests unconformably on the Holston marble. In the belt next to the east the Tellico still is in contact with the Holston, but the *Telephus* zone lies about 300 feet above the base of the Tellico. In the belt next to the east the Holston is commonly entirely wanting, and where any beds of it are found they are succeeded by from 1,000 to 4,000 feet of Athens shale before the section reaches the base of the Tellico.

Cotypes.—Cat. Nos. 80531, 80532, U.S.N.M.

TELEPHUS TRANSVERSUS, new species

Plate 6, Figures 20, 21

This species is represented by a single good cranidium that was found in association with numerous heads, free cheeks, and pygidia of *T. tellicoensis* and *T. hircinus* in the Tellico formation east of Knoxville, Tenn. Though obviously very closely related, it was at once distinguished from the common associated forms by its even shorter, more transverse form, the lesser convexity, greater posterior width, lowly ridged contour, and flattish slopes of the glabella, and the greater width of the frontal rim. As in *T. tellicoensis*, a very shallow, obscurely defined broad pit lies near the middle of the lateral slopes of the glabella. These pits, though much shallower than the corresponding impressions in *T. bipunctatus*, nevertheless, as does also the cranidium as a whole, remind of that older species. However, critical comparisons indicate other slight differences that help in warranting the specific distinction here credited to the two forms. Thus, the broken base of the occipital

spine indicates a spine of larger size than occurs in *T. bipunctatus.* The anterior spines also are larger, and the rim from which they spring is slightly thicker than in that species. More conspicuous is the greater posterior width of the glabella. Finally, the posterior end of the fixed cheeks is wider, the raised outer edge of the palpebral band correspondingly more longitudinal in direction, the anterolateral angles more bluntly rounded, and the convex area of the cheek more uniformly convex.

Although none of these structural differences is very conspicuous or impressive it is nevertheless true that hardly a single cranidial feature is precisely alike in the two. Now, since the differences have been determined and pointed out it seems unlikely that others will have as much difficulty in distinguishing properly prepared specimens as I had in working them out. Besides, there is always the chance that more striking structural differences may be found in the as yet unknown other parts of the animals. But, after all, the main reason for taking the trouble of determining the differences by which successive stages in the evolution of fossil organisms may be distinguished and recognized lies in the increasingly great need of unquestionable guide fossils.

The present species is related also to *T. mobergi* Hadding, but the differences in this case are too readily determinable by comparison of their respective illustrations in following plates to require further notice here.

Occurrence.—Ten feet above base of Tellico formation at quarry on south side of Tennessee River, one and one-half miles east-southeast of Southern Railway station in Knoxville, Tenn. A few specimens were found also in the Tellico belt next to the east about 6 miles east of Knoxville. At this place the species is associated with *T. hircinus* and a multitude of Bryozoa in an oolitic and ferruginous limestone conglomerate about 300 feet above the base of the formation.

Holotype.—Cat. No. 80534, U.S.N.M.

TELEPHUS HIRCINUS, new species

Plate 7, Figures 1–9

Distinguished from other species mainly by its great posterior convexity, stronger neck spine, thicker occipital ring, the larger size and more anterior direction of the anterior spines, and relatively narrower anterior rim. The glabella is broadly rounded-conical in outline, has somewhat flattened slopes with obscurely defined and very shallow depressions representing the second pair of furrows. Surface nearly smooth with obscure striations on the post-median (highest) part of the glabella and on the anterior slopes of the fixed

cheeks. The latter are of moderate size and convexity and rounded in outline.

T. hircinus is larger than *T. bipunctatus* but evidently is allied to it and may indeed, like *T. tellicoensis*, have been derived from it. However, the characters mentioned will, it is believed, serve satisfactorily in distinguishing them. None of the other species seem close enough to require detailed comparison.

Occurrence.—Rare in a highly fossiliferous ferruginous oolitic and crystalline limestone, about 6 feet thick, intercalated in ordinary calcareous Tellico sandstone in the middle third of the formation, 6 miles east of Knoxville, Tenn. Also in the basal 10 feet of the Tellico in the band one mile southeast of Knoxville. At both places it is associated with *T. tellicoensis* and *T. transversus.*

Cotypes.—Cat. No. 80548, U.S.N.M.

TELEPHUS BILUNATUS, new species

Plate 6, Figures 8, 9

A small species known only from its cranidium. This is relatively longer and rounder than in most others of the genus, has small fixed cheeks with the convex areas of same narrow, carinated, and curved, the glabella strongly convex and, including the neck ring, subovate in outline, with a deep sharply impressed crescentic glabellar dimple in either slope, the neck furrow deep and wide, and the occipital ring but little wider than the furrow with a small posteriorly directed spine and in front of this on the anterior edge of the ring a small conical elevation that may have served for visual purposes. Surface apparently quite smooth.

In general aspect this small trilobite head resembles the corresponding part of *T. mysticensis*, but it is distinguished at once by the strongly impressed crescentic glabellar dimples. These impressions are even more sharply defined than in *T. bipunctatus*, and their outwardly bowed form gives the head so characteristic an appearance as to forbid any thought of its reference to any other of the known species. Hadding's *T. mobergi* may be as near as any, but in that species the antero-lateral part of the outline of the cranidium is more angular, the glabella more depressed convex, and the crescentic glabellar depressions are convex inwardly instead of outwardly.

Occurrence.—A rare fossil in the Whitesburg limestone near Albany, Tennessee. Here it was found associated with many remains of heads and other parts of *T. bipunctatus.*

Holotype.—Cat. No. 80529, U.S.N.M.

TELEPHUS BUTTSI, new species

Plate 5, Figure 16

The holotype of this perhaps doubtful species is a very small cranidium with an extremely long, slender, and rounded occipital spine. Two other, in all respects similar, cranidia were found with it in the same slab of shale. Slight variations in shape of these three specimens and in associated fossils of other classes indicate that the figured holotype has suffered sufficient compression to have reduced its original longitudinal dimensions by possibly a fourth. On realizing this its resemblance to *T. bipunctatus*, which has been noted already by comparison of their respective illustrations in Plate 5, is correspondingly enhanced. Possibly it actually belongs to that species, in which case the extraordinary length of the occipital spine would be merely a character of youth. However, it is not so easy to explain the sharply angular post-lateral extremities of the glabella and also the greater obliquity and more posterior position of the pair of glabellar furrows. The anterior spines also are more divergent and more prominent in dorsal views than in *T. bipunctatus*. For these reasons it seems best to treat these small specimens as representatives of an independent species. It is named for Dr. Charles Butts, who discovered the outcrop of shale in which they and many other interesting fossils were found by him and subsequently by Mr. R. D. Mesler.

Occurrence.—The types of *T. buttsi* and also the specimens referred to the following *T. troedssoni* come from a yellow leached shale at the base of a considerable thickness of dark colored, hence more normal, Athens shale, one and one-half miles northeast of Longview, Ala. With these remains of *Telephus* occur other similarly distorted trilobites—among them *Robergia athenia* Butts and undetermined species of *Agnostus*, *Harpes*, and *Ampyxina;* also *Turrilepas* and various brachiopods. Most of these suggest the Whitesburg limestone horizon rather than typical Athens.

Holotype.—Cat. No. 80546, U.S.N.M.

TELEPHUS TROEDSSONI Raymond

Plate, 5, Figures 17–21

Telephus troedssoni RAYMOND, 1925, Mus. Comp. Zoöl. Bull., vol. 67, No. 1, p. 66 (not figured).

Cf. *Telephus mobergi* HADDING, 1913, Geol. foren. Forhandl., vol. 35, p. 37, pl. 2, figs. 12–17 (reproduced in pl. 2 of this work).

Raymond's description is as follows:

Cranidium small, moderately convex, with broad flaring palpebral lobes which enlarge toward the front. Glabella ovate, tapering considerably toward the front, bearing only one pair of furrows, which are obliquely directed depressions

which do not connect with the dorsal furrows. The nuchal ring is wide, and bears a long slender median spine. The specimen is a cast of the exterior, and shows a very fine granular ornamentation on the palpebral lobes.

Measurements.—The cranidium is 4.00 mm. long and 5.00 mm. wide across the palpebral lobes near the front. The glabella is 2.25 mm. long, and 3.00 mm. wide at the base. The nuchal spine is about 1.25 mm. long.

This species appears to be most closely allied to *Telephus mobergi* Hadding (Geol. foren. Forhandl., 1913, 35, p. 37, pl. 2, fig. 12–17), agreeing with that species in the possession of one pair of glabellar furrows, which, however, are differently placed, and in having ornamentation only on the palpebral lobes.

T. troedssoni differs from *T. americanus* Billings in that the glabella tapers more rapidly forward, and in possessing a nuchal spine.

Horizon and Locality.—A single cranidium was found by the writer in Athens shale associated with *Nemograptus gracilis* in a cutting on the railroad 2 miles northeast of Athens, Tenn. Named for Dr. Gustav Troedsson who was with me when the species was found. Holotype (M. C. Z. 1,723).

Study of Raymond's poorly preserved holotype of this species and of the clay mold of it that is illustrated in Plate 5, Figure 17, suggests that it is really a closer ally of Hadding's *T. mobergi* than is indicated by the above quoted description. The exterior ornamentation of the fixed cheeks, or palpebral lobes as Raymond calls them, is nearly obliterated, but its remains leave little doubt in my mind that it was not of the granular kind but rather of the reticulated type that occurs in *T. mobergi* and is perhaps best developed in such American species as *T. bipunctatus* and *T. prattensis*. Certain obscure thin longitudinal ridges on the posterior half of the glabella also suggest remains of the kind of ridging of the corresponding parts of the exterior surface of the head that prevails in the mentioned Swedish and American species. Neither the reticulation of the cheeks nor the longitudinal ridges of the glabella seem ever to show on clean casts of the interior.

A few more or less distorted specimens, comprising a couple of cranidia, a free cheek, and a pygidium from basal Athens near Longview, Ala., that prior to seeing the type of *T. troedssoni* I had referred with question to *T. mobergi*, may very well be conspecific with Raymond's species. There are some differences when we compare these Alabama specimens with the illustrations of the mentioned Swedish species on the one hand and with the type of *T. troedssoni* on the other. But since the latter species has been established and though closely related to is yet distinguishable from *T. mobergi*, and as I find it easier to explain the observed accidental differences from the type of *T. troedssoni* than I can account for the differences noted in comparing the Alabama specimen with the Swedish species, it seems best for the present to refer them to Raymond's species.

A few statements regarding each of the Alabama specimens here under consideration and illustrated on Plate 5 may be desirable.

Figure 18 is of a cranidium that obviously has been distorted by reduction of its original transverse dimensions. Its interest lies particularly in the presevation and clear separation of the two pairs of anterior spines. These spines are only very obscurely indicated in the holotype of the species shown beside it in Figure 17.

Figure 19 is an untouched photograph of a distorted and incomplete free cheek. It probably belongs to this species, this opinion being mainly based on the fact that it reminds of the cheeks of *T. mobergi* and *T. bipunctatus*, both of which must on other grounds be viewed as close allies of *T. troedssoni.*

Figure 20 also is an untouched photograph of a cranidium that can be referred to this species only provisionally. Though doubtless much distorted by compression that has reduced its original longitudinal dimensions by perhaps as much as a third, it is hardly conceivable that its present shape could have been achieved by compression of a cranidium like that of either Figure 17 or 18 in the same plate. Though the surface of the glabella shows some irregular undulations none of the slight depressions could represent the dimple-like furrows that occur on those cranidia. It probably represents a form more nearly like that of such younger species as *T. hircinus* and *T. tellicoensis*, in which the glabella is without furrows.

Figure 21 is taken from an associated pygidium. Though the original indicates reduction in length by compression of the shaly matrix the width of the border behind the axis is still notably greater than in any other species of the genus of which the pygidium is known. Though possibly the tail of the associated *T. buttsi* its reference to *T. troedssoni* seems the most likely to prove correct.

Plesiotypes.—Cat. No. 80477, U.S.N.M.

Genus GLAPHURUS Raymond

GLAPHURUS PUSTULATUS (Walcott)

Plate 7, Figures 15, 16, Plate 8, Figures 1–11.

Arionellus pustulatus Walcott, 1880, 31st Ann. Rep. New York State Mus. Nat. Hist., p. 68; adv. sheets of same 1877, p. 15.

Sao (?)Lamottensis Whitfield, 1886, Bull. Amer. Mus. Nat. Hist., 1. p. 334, pl. 33, figs. 9–11.—Brainerd and Seely, 1890, Bull. Amer. Mus. Nat. Hist., 3, p. 22.—Lesley, 1889, Geol. Surv. Pennsylvania Rep., P. 4, p. 825, figs. (copied from Whitfield.)

Agraulos (Arionellus) pustulatus Vogdes, 1890, Bull. U. S. Geol. Surv., No. 63, p. 90.

Glaphurus pustulatus Raymond, 1905, Ann Carnegie Mus., vol. 3, p. 357, pl. 14, figs. 4–6; 1910, vol. 7, p. 74, pl. 18, figs. 9–11; 1910, 7th Report Vermont State Geol., p. 234, pl. 36, figs. 4–6, and pl. 38, figs 9–11; also Grabau and Shimer, 1910, and Perkins, 1912, who reproduces Raymond's figures of the species.

As the previously published illustrations of this interesting and extremely spinose trilobite are not very good and fail to bring out

some of its most important structural features I have endeavored to supply the desired information by devoting nearly an entire plate to the illustration of its parts. The accurately figured specimens shown in Plates 7 and 8 do not include either of the two complete individuals that are comprised in the material before me but consist mainly of separated parts of the dorsal shield that show many previously unrecorded details of structure. Most of these features are mentioned in the descriptions of the figures in the plates to which the reader is referred. However some of them deserve further discussion here.

To begin with I will call attention to the extremely spiny nature of the surface of the cephalon and thorax. The pygidium, on the contrary, has no spines but its surface is covered with very small tubercules. Of course, as a rule only the broken stumps of these spines are to be seen on the specimens as they show on the fractured surface of the fine grained limestone matrix. It is only here and there, as for instance at the left end of the occipital ring of the cranidium in the left half of figure 2, that one gets an adequate conception of the great length and extreme slenderness of many of these spines. The length of those on the pleural parts of the thoracic segments is shown on the right side of figure 1. Those on the axis appear to be shorter.

The ends of the thoracic segments, of which there are 10, are not drawn out into recurved spines, as indicated in Whitfield's figure of the thorax, but are simply turned sharply downward and terminate somewhat bluntly and obliquely, the free edge being lined with a fringe of minute spines, the posterior one of which is thicker and much longer than the others.

Another set or fringe of very small spines that seems to have been overlooked previously occurs, as shown in figure 4, along the outer edge of the free cheek. Regarding the free cheeks it should also be observed that the two, as shown in figure 5, are connected across the front by a narrow, parallel-sided, doublure-like band. However, this band seems to be separated from the rim of the dorsal part of the test by a suture along the anterior edge of the cephalon. The strong arching of the edge of the cephalon in the anterior view and the two relatively strong spines on the anterior rim of the cranidium are other noteworthy features.

The facial suture cuts the posterior margin immediately behind the base of the genal spine. In fact it seems to cut off a bit of the base of the spine. Anteriorly it cuts the rim just outside of the lateral extremity of the glabella.

Among many strictly specific characters is the fact that there are constantly three transverse rows of spines on the preglabellar field.

So far as known *Glaphurus pustulatus* is confined to a narrow, sometimes reef-like zone that I believe lies at the base of the Upper Chazy limestone at Isle La Motte and other places in the Champlain Valley.

Paratypes.—Cat. No. 88051*a-h*, U.S.N.M.

GLAPHURUS LATIOR, new species

Plate 8, Figures 12, 13

This name is proposed for a rare southern Appalachian representative of the genus of which only the cranidium has been found. It attained larger dimensions than *G. pustulatus* and differs structurally from it mainly in that the cranidium is relatively wider posteriorly and that there are only two instead of three transverse rows of spines cross the middle part of the preglabellar field. Other small differences may be observed in comparing the figures of the two species in following plates.

Occurrence.—The holotype was found in the Whitesburg limestone, 6 miles southwest of Bland, Va. Another was found with *Telephus bipunctatus* at Pratts Ferry, Ala.

Holotype.—Cat. No. 80552, U.S.N.M.

GLAPHURINA, new genus

Glaphurus part Raymond, 1925, Mus. Comp. Zoöl. Bull., vol. 67, No. 1, p. 130.

Raymond included at least one of the species referred to this new genus in *Glaphurus* when he described *Glaphurus decipiens* in the work above cited. In the description of the mentioned species he speaks also of southern Appalachian specimens of cranidia that he identifies with it. One of these he collected from a limestone southeast of Bluff City, Tenn., that he calls "Lower Lenoir," and this most probably is the form for which I am proposing the name *Glaphurina falcifera.* The other he obtained "from the Holston limestone in the Catawba Valley, north of Salem, Va.," and this may be of the species for which I am proposing the name *Glaphurina brevicula.* That these two southern cranidia are not strictly conspecific is rendered highly probable by the widely different zones in which they were found. If they are, as I think, clearly distinguishable, stratigraphic considerations demand their separation under names of their own. With such loose identifications of fossil species progress and definite results in working out the sequence of Ordovician deposits and events in the Appalachian Valley, or indeed any where else, are simply impossible.

Whether either of these southern Appalachian Valley species is the same as the Mingan Islands species can not be determined without direct comparison of specimens. Now I can say only this, that

if the figure of "a nearly complete cranidium," which presumably represents the largest of the four cranidia collected by Professor Twenhofel on Bald Island, is reasonably correct, it can not be the same species as either of the southern forms nor the same as the Champlain Valley species that I am calling *Glaphurina lamottensis*. Still, I see no reason to doubt that the Mingan Islands species also belongs to this genus and, if the new genus is accepted, it will hereafter be known as *Glaphurina decipiens*.

These apparently four species all differ from true *Glaphurus* in lacking the preglabellar field which in that genus intervenes as a broad spinose band between the glabella and the anterior furrow and rim. They differ further in lacking the anterior glabellar furrow though a suggestion of it occurs in *Glaphurina falcifera*. Finally the surface of the cranidium is merely pustulose and not spiny as in *Glaphurus*.

Genotype.—*Glaphurina lamottensis*, new species.

Occurrence.—Lower and Upper Chazyan, Champlain Valley, Mingan Islands, Virginia, and eastern Tennessee.

GLAPHURINA LAMOTTENSIS, new species

Plate 8, Figures 14–16

Two cranidia, neither complete yet both in reasonably good condition, are available of this species. The three views of the larger are as nearly correct as they could be made. They fail mainly in that the smaller set of surface pustules, or rather small granules, which are scattered between the larger set and clearly visible in the photographs, do not show in the halftone reproduction. In the triconvex anterior outline and in the general form of the glabella the dorsal views of these cranidia resemble Raymond's figure of *G. decipiens* but the sides of the glabella are more curved and more convergent to the front so that the glabella is narrower anteriorly and less quadrate and the middle part of the tri-convex anterior outline of the cranidium shorter than it appears to be in the typical form of Raymond's species. If the concerned parts are accurately represented in that illustration it seems improbable that these Champlain Valley specimens can be of his species.

Comparison of their respective figures on Plates 7 and 8 shows clearly enough that *G. lamottensis* is quite distinct also from both *G. brevicula* and *G. falcifera*. As will be mentioned in following notes on the latter there is another as yet unnamed species in the bed that supplied the types of *G. falcifera* that is a nearer ally of *G. lamottensis* than either of the named forms from southern Appalachian localities.

Occurrence.—Associated with numerous specimens of *Glaphurus pustulatus* in the basal bed of the Upper Chazy on Isle La Motte, Vt.

Holotype.—Cat. No. 80553, U.S.N.M.

GLAPHURINA BREVICULA, new species

Plate 7, Figures 17–19

This species is based on a single imperfect cranidium that has a shorter glabella than any of the other species assigned to this genus and seems to differ also in other details from them.

Occurrence.—Holston limestone, 2 miles northwest of Lexington, Va.

Holotype.—Cat. No. 80549, U.S.N.M.

GLAPHURINA FALCIFERA, new species

Plate 7, Figures 20, 21

Of this species we have four cranidia, all more or less imperfect in outline. The glabella is nicely rounded in front and wider in its anterior third than in the other species of the genus. The glabellar depressions also differ in details, the posterior one being double and its parts so arranged that they form a crudely executed figure resembling a sickle that suggested the specific name. As will be noted in studying figure 21, there is a shallower depression in front of the deeper ones. Together they suggest and probably represent the usual first, second, and third pairs of glabellar furrows. The glabella and fixed cheeks are covered with regularly spaced tubercles of moderate and approximately equal size.

With these typical specimens occurred another cranidium in which the sides of the glabella converge more rapidly forward, the glabellar pits apparently a single, altogether more simple pair, and the surface tubercles distinctly of two sizes, with most of those covering the glabella, the posterior slopes of the fixed cheeks and the middle part of the occipital ring decidedly smaller and much more crowded than in the holotype and other specimens that are included in the types of the species. In the mentioned respects this unique cranidium comes closer to *G. lamottensis* than to *G. falcifera* without, however, being enough like the former to be regarded as the same species. Evidently the Lower Chazyan of Tennessee contains a second species of *Glaphurina* that remains to be figured and named. Unfortunately its sole known representative had not been discovered when the plates of the present paper were made up.

Occurrence.—Found in an as yet unnamed Lower Chazyan limestone formation that underlies a typical but thin development of the Lenoir limestone and rests unconformably on the Middle Cana-

dian *Lecanospira* zone on Indian Creek, one and a half miles southeast of Bluff City, Tenn.

Holotype.—Cat. No. 80550, U.S.N.M.

STRATIGRAPHIC AND GEOGRAPHIC RANGE OF TELEPHUS AND CORRELATION OF FORMATIONS

Range and origin of Telephus faunas.—In the Appalachian Valley remains of *Telephus* are confined to areas in the eastern half of the valley south of Staunton, Va., and in the north to a few places in southeastern Canada. All these occurrences are in faunas that are clearly of Atlantic (Poseidon) origin. This conclusion is based mainly on two facts: First, that *Telephus* and nearly all of the remainder of the faunas in which species of this genus of trilobites occur are wholly absent in the Ordovician deposits in most of the western half of the Appalachian Valley. The latter, on the other hand, agree in lithic and faunal characters with the Ordovician deposits in the Ohio Valley. Second, the faunas of the Blount group, which include species of *Telephus* and many other genera that are found in America only in the eastern belts of the Appalachian Valley, are represented by very similar and in some cases perhaps indistinguishable species in related and in part perhaps contemporaneous formations in southeastern Canada, Scotland, Norway, Sweden, and Bohemia.

In Virginia, Tennessee, and Alabama the first appearance of *Telephus* is in the Whitesburg limestone. It is this formation also that gave us 8 of the 15 or 16 species described in this paper from southern Appalachian localities. Of the remaining species five came from overlying Athens shale and three from the succeeding Tellico. The vertical range of the genus therefore seems as well fixed in the sequence of Upper Chazyan deposits in the Appalachian Valley as in its geographic range. Further, in view of its restricted occurrences in the St. Lawrence Valley and Newfoundland and, on the other side of the Atlantic, in southern Scotland, Sweden, Norway, and Bohemia it seems fairly clear that the type originated in and dispersed from the middle Atlantic basin.

In America, as in northeastern Europe, *Telephus* is often associated with species of such other genera of trilobites as *Ampyx*, *Lonchodomus*, *Ampyxina*, *Robergia*, *Remopleurides*, *Dionide*, *Salteria*, *Trinucleus*, *Bronteopsis*, and *Nileus*, all of which I regard as also indigenous to the middle Atlantic Basin. None of them has been found in Cordilleran faunas or Chazyan or younger Ordovician ages that were developed in the Arctic and Pacific realms nor in the Ordovician faunas in the Mississippi and Ohio Valleys that are thought to have invaded the continent from the south. Nor have they been found in the typical Chazyan in the Champlain Valley or,

with the exception of *Lonchodomus* and *Remopleurides*, in the Lower and Middle Chazyan and the Holston and Ottosee formations of the Blount group in the southern Appalachian belts. Seperation of Paleozoic faunas according to their geographic origin is discussed at considerable length in following pages.

Trilobites preferred to graptolites in trans-Atlantic correlations.—In my estimation *Telephus* and the other above-mentioned genera of Atlantic trilobites are at least as dependable criteria as the highly esteemed graptolites in correlating formations in America with those in Europe. Still these problems are never simple; and too often the fossil evidence is not as definitely indicative of time relations as it may seem. In a recent paper [18] I showed that the graptolites—mainly because their preservation is usually too imperfect to permit of the required intensive study and comparison of minute structural details—are as yet only a rather coarsely graduated standard of measurement. Nor is the evidence of the trilobites or of any other class of fossils easily evaluated. Closely similar species are found on the two sides of the Atlantic, but other means must be employed before we may be warranted in concluding that the observed slight differences between the compared forms indicate merely locally developed contemporary modifications or that they are variations from type that required long periods of time to produce. And even when two occurrences on opposite sides of the sea can not be satisfactorily distinguished the fact by itself is not determinative as to their practical contemporaneity unless the remains are complicated in structure and they agree in biblogically unimportant structural features.[19] It is only after the finest possible differentiation of congeneric species or varieties has been carried out that detailed correlation of their respective zones is validly permissible.

In the Appalachian Valley, from central Alabama to, say Staunton, Va., the occurrence of specifically identical forms of the trilobite genera mentioned above may be accepted as reasonably conclusive proof of the essential contemporaneity of the beds containing them. Corroboration of the validity of this conclusion is found in the fact that the species of *Telephus* and other genera of trilobites that are regarded as belonging only to the zone of the Whitesburg limestone are always found only beneath the lowest occurrence of the Normanskill graptolites and of the trilobites that in southern Appalachian belts commonly occur either in the same layers

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[18] Relative values of criteria used in drawing the Ordovician-Silurian boundary, Geol. Soc. America Bull., vol. 37, p. 301, 1926. Because they tend to amplify facts presented in this paper concerning differences on the two sides of the Atlantic in the vertical range of graptolites that in Britain are regarded as reliable horizon markers it seems worth while to direct the reader's attention to paragraphs on pp. 179 and 180 of Troedsson's 1928 work on the Middle and Upper Ordovician Faunas of Northern Greenland.

[19] See Ulrich, E. O., Correlation by displacements of the strand line, Geol. Soc. America Bull., vol. 27, p. 488, 1916.

with the graptolites or by themselves in the basal quarter of the Athens shale. This is true whether the Athens consists entirely of the shale facies or begins with or consists entirely of the limy facies. The case, however, is very different when we try to fix the position of the *Telephus* occurrences in southeastern Canada in the sequence of Chazyan deposits in the southern Appalachian troughs. The species in the former region are not precisely the same as their congeners in the south. None of the latter could be unquestionably identified with *T. mysticensis*, which is the name proposed in the paleontological part of this paper for the species found in the limestone conglomerate near Mystic in the southwestern corner of Quebec.

Absence of Telephus faunas in Champlain Valley.—Except the Valcour limestone, which is the top limestone of the Chazy in the Champlain and St. Lawrence Valleys and probably falls into some undetermined part of the stratigraphic span covered by the Blount group of east Tennessee, no deposits of Blount age occur in place between Virginia and the Mingan Islands in the Gulf of St. Lawrence. Disregarding the Valcour—mainly because its fauna is quite dissimilar to all but the highest (Ottosee) fauna of the Blount—we may therefore assume that the Appalachian troughs north of Virginia and south of Canada were emerged during the deposition of the 6,000 feet or more of beds comprised in the Holston, Whitesburg, Athens, and Tellico formations of east Tennessee and in the second, third, and fourth of which remains of *Telephus* are found. If we were to assume that the Tellico occurrences of *Telephus* marked the termination of the existence of the genus we might then conclude that the occurrences of the genus in Canada and Europe are older than the top of the Tellico. But we would have to assume or prove also that the foreign occurrences are not older than the Whitesburg limestone before we could say that any of the concerned Chazyan formations on the two sides of the Atlantic are contemporaneous.

Discussion of age relations of faunas in Scotland to Appalachian faunas.—On the basis of direct faunal comparisons it seemed at first one might find sufficient evidence to indicate that the Balclatchie group in the Girvan District in Scotland—from which Reed described *Telephus salteri*—comes nearer to an agreement with our Whitesburg limestone than with any other of the Appalachian formations. Corroboration of this suggested correlation appeared also in the fact previously pointed out by Raymond [20] that species of *Dionide* occur

[20] Raymond, P. E., Some trilobites of the Lower Middle Ordovician of eastern North America: Harvard Coll. Mus. Comp. Zoöl. Bull., vol. 67, No. 1, p. 179, 1925.

in the Girvan District only in and perhaps above the Whitehouse group, which succeeds the Balclatchie, whereas in America the genus is confined to the Athens shale, which succeeds the Whitesburg. However, after seeing the concerned beds in Scotland and reconsideration of the evidence in the light of personal observation of facts not previously available to me, the suggested correlation of the Balclatchie and Whitesburg has become quite impossible. In fact, nothing is left of it than the conviction that the faunas of the two formations were derived from the same Middle Atlantic realm. But they did not receive them at the same time, the Balclatchie invasion of Scotland having occurred long subsequent to the Whitesburg, and after considerable modification and change of the earlier composition of the Middle Atlantic fauna had been introduced. The probable truth of this statement is rather plainly indicated by the fact that not a single species has been found in either formation that is strictly the same as any in the other. Also by the fact that the Balclatchie fauna includes many types that are unknown in Appalachian faunas that contain species of Middle Atlantic origin and are of older dates than the Ottosee, Little Oak, and Chambersburg faunas. The latter fact thus tends to confirm the conclusion that is more satisfactorily substantiated by considerations about to be presented.

In the first place, the lower age limit of the Balclatchie may be said to be conclusively fixed—at least in the minds of British geologists who rely so strongly in their Lower Paleozoic correlations on the evidence of graptolites—by the fact that it is underlain by a shaly zone that contains Glenkiln graptolites. The Glenkiln, as all agree, represents the Normanskill and Athens shales of the Appalachian geosyncline. It follows, then, that the Balclatchie is not only younger than the Whitesburg but also younger than the Athens. Following this conclusion it seemed at first that the Balclatchie might be correlated with our Tellico. This correlation found considerable support in the similarity of the pelecypodan parts of the faunas of the two formations; but again the entire lack of specific identities casts doubt on its validity. Besides, the numerous brachiopods of the Balclatchie include many species that not only look younger than Tellico representatives of the class but indicate a stronger commingling of northern and Middle Atlantic types than we have reason to believe occurred before the close of Blount time. I may mention, too, that the inconspicuous development of the glabellar furrows and the presence of a nucal spine in the Balclatchie *Trinucleus subradiatus* Reed suggests a *Cryptolithus* rather than a *Tretaspis*, to which genus it is referred by Stetson.[21] Similar species occur in America only above the Chazyan.

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[21] Stetson, H. C., The distribution and relationships of the Trinucleidæ: Harvard Coll. Mus. Comp. Zoöl. Bull., vol. 78, No. 2, p. 88, 1927.

Probably a more important fact is the recent discovery of excellent specimens of a species of *Salteria*—which I propose to name *Salteria oderi* after its discoverer—in a shale formation of Black River age near the Massanutten Caverns in northern Virginia. This new American species is a close but distinguishable ally of the Balclatchie type of the genus, *S. primaeva* Wyville Thomson. The vertical range of this genus in both Scotland and America being very limited the correlation significance of its two known species may well be more definite than is that of allied species of more prolific and more persistent genera common to Britain and North America.

The American species of *Salteria* was found in an elsewhere as yet unknown and geographically probably very limited formation of mainly soft yellow or yellowish-gray calcareous shale, 300 to 400 feet thick, that lies directly beneath a great mass of darker Martinsburg shale (Trenton and Cincinnatian) and rests apparently without intervention of other deposits on a fair development of Athens shale. Absence of the missing beds in this area is not extraordinary because it has been known for 20 years that the Athens is the only formation of the Blount group that extends so far north in Virginia.

This new formation has already provided many new fossils besides *Salteria oderi*. Among them I may mention 8 or 10 species of graptolites, 1 or 2 species of *Tretaspis*, 2 species of *Calymene*, a species of *Encrinurus* allied to *E. punctatus*, a *Tornquistia*, and a *Dalmanella*. The brachiopod and all of the trilobites are more or less closely related to Balclatchie species. Moreover, the species of *Calymene* mark the first appearance of their generic type in both North America and southwestern Scotland. The graptolites are of particular interest and stratigraphic significance in showing intermediate stages of development between those prevailing in the Normanskill and Athens and those marking Trenton stages. The only reasonable conclusion to be reached from my study of this fauna is that it represents an invasion of the Appalachian trough by a Middle Atlantic fauna during some Black River age that, so far as known, left no depositional record elsewhere in North America.

In view of these facts and logical deductions I feel impelled to give the Balclatchie a higher position in the American section than I formerly believed warranted. Perhaps it should go even a notch higher than I have given it in the correlation chart on page 73.

To further illustrate the difficulties of correlating Ordovician and Silurian formations on opposite sides of the Atlantic is seems worth while to give a brief account of the blind trails followed before I knew positively that the Balclatchie is underlain by shale with Glenkiln-Athens graptolites. Naturally, I began the present inquiry with a detailed study of Reed's monographs of the fossils of the Girvan district. The Drummuck seemed fairly easy, but none of the three

underlying formations, Whitehouse, Balclatchie, and Stinchar—the brachiopods and trilobites of which he described—seemed to offer any decisive clues at all. In the case of the Stinchar, as is rather fully brought out in the notes on the British column of the correlation table (see p. 84), the amazingly contradictory faunal evidence included in Reed's list of its fossils served mainly in upsetting every hypothesis that suggested itself. Then after noting the large proportion of species said to be common to the Stinchar and the Balclatchie and at the same time the species in both that should, according to American standards, be much older, I could only assume that either many types began much earlier in Scotland than in our sequence of formations or as many or more began much later. Considering that Reed recognized the relations of the Girvan faunas as closer to those of America than usual with British faunas this state of affairs seemed inexplicable. Something appeared to be wrong but what it might be could not be determined till my visit to Scotland the past summer and after the discovery of new evidence in northern Virginia a few months before.

However, in seeking to force some conclusion out of the tangled skein of fossil evidence I directed my efforts particularly to the trilobites in the Balclatchie and the Whitehouse lists. These gave the impression that the Balclatchie is as old as the Whitesburg or at least not younger than the Athens. This possible conclusion was suggested by the following facts: First, the nearest allies of the Balclatchie species of *Ampyx* and *Lonchodomus* seem to be those found in the Whitesburg limestone and in the Athens shale. The Whitesburg also contains a trilobite very similar to *Tornquistia* cf. *nicholsoni* Reed, a Keisley limestone species identified by that author in both the Balclatchie and the Whitehouse of the Girvan district. Another fact that was given some weight is the occurrence of several species of Acidaspidae in the Whitesburg limestone of Tennessee and Virginia that fall into Raymond's new genus *Onchaspis* and are closely similar to species described by Reed as found in the Balclatchie. Then there is the Balclatchie species *Remopleurides barrandei*, which again is much like some of our Whitesburg and Athens species.

The Scotch species of *Telephus* also seemed to point to some perhaps low horizon in the Blount. The older of the two, *T. salteri* Reed, was found in the Balclatchie. But the holotype of this differs so much from all other species of the genus that I am still at a loss to decide which of them it resembles most. For the present then its significance in stratigraphical correlation is inappreciable. The other species is credited to the Whitehouse group and was referred by Reed to the Bohemian genotype, *T. fractus*. Study of the specimens in the British Museum that were used by Reed has convinced me that

this Girvan species of *Telephus* is neither the same as Barrande's type of the genus nor precisely like any of the other European and American species. I have therefore proposed the new name *Telephus reedi* for it. On comparison with other species it proved to be more nearly related to the Swedish *T. wegelini* and the Athens *T. latus* than to *T. fractus*. Whatever bearing *T. reedi* may have on the question of the stratigraphic relations of the Girvan formations to Appalachian deposits it seemed—as did also the already mentioned alliances of Balclatchie and Whitehouse species of *Ampyx*, *Remopleurides*, *Dionide*, and *Onchaspis*—to favor correlation of the Balclatchie and the Whitehouse with the lower formations of the Blount group. And this conclusion was indicated also by the apparent trend of the evidence of the trilobites—a group of animals that undeniably is more highly organized than the brachiopods and therefore expected to offer the more exact correlation data; a supposition that in this instance failed to be substantiated. However, in justice to the trilobites, it must be admitted that some of the compared species suffered greater disadvantages than the brachiopods in requiring comparison of more or less fragmentary specimens.

With such contradictory, and in other respects indecisive fossil evidence, the formerly existing extreme difficulty of satisfactorily correlating the Ordovician and Silurian formations of Europe with those in America is evident. However, with the developments of the present year, partly described on preceding pages and supplemented in notes on the British column of the following correlation table (see p. 83), the chances of finally reaching fairly definite results seem much more promising than they were a year or two ago. In fact, though still speaking in somewhat generalized manner, we are now probably warranted in correlating the typical Stinchar limestone [22] with the Lenoir limestone and the shale with Glenkiln graptolites that lies between the Stinchar and the Benan conglomerate with some part of the Athens shale of the Blount group. The succeeding Balclatchie, Ardwell, and Whitehouse groups are less definitely referable to positions in the Appalachian sequence. Still, I feel reasonably certain that they are post-Chazyan in age and that the positions to which they are tentatively assigned on the correlation chart are, if not quite correct, at least nearer the truth than were the conclusions respecting their relations to American formations published a few years ago by Raymond [23] in the stratigraphic part of his work on Ordovician

[22] For reasons given on page 84, the designation "typical Stinchar limestone" does not include the doubtless much younger limestone of the Craighead quarry which supplied by far the greater part of the fossils mentioned in Reed's lists of Stinchar limestone trilobites and brachiopods besides many other species of classes, especially corals, not monographed by him.

[23] Raymond, P. E., Harvard Coll. Mus. Comp. Zoöl. Bull., vol. 67, No. 1, pp. 163–180, 1925.

trilobites of eastern North America and in a more recent paper by the same author and Willard on Chazyan brachiopods in Tennessee and Virginia.

The need of studying the papers on Appalachian brachiopods by Raymond and Willard arose only since the completion of the present work. The new species described and others identified in these papers attain the respectable total of 73 species. It is to be noted also that the species have been discriminated with uncommon attention to external details of shell structure. Still it is evident that their collections from the Chazyan deposits in the southern Appalachian Valley and those from the Stones River limestones in central Tennessee are far inferior, both as regards quantity and quality, to those accumulated in the National Museum by me and my associates. With more and better material probably neither Raymond nor Willard would have identified so many of the Virginia and Tennessee species with Champlain Valley Chazyan and Mississippi Valley Stones River and Black River species. It seems probable also that they would have found that some of the identified or supposedly closely allied species are even only doubtfully assignable to the same genera. But my strongest criticism of both the brachiopod and the preceding trilobite paper concerns the stratigraphic assignments of many of the species. I have studied and collected from all the Virginia and Tenessee localities mentioned in these papers and therefore am prepared to say that many of the asserted occurrences of strictly the same species in two or more of the Chazyan formations are based on mistaken identifications of beds. Indeed, these stratigraphic inaccuracies are so numerous that they very seriously impair the validity of Raymond's conclusions [24] regarding the relationships of the Chazyan fossils of Tennessee and Virginia.

Cause of difficulties in correlating European and American Ordovician formations.—Aside from erroneous or merely loose identifications of fossils and misunderstandings, the main cause of our troubles in this connection lies in the indisputable fact that we are dealing with successive and slowly modifying aspects of the generally very different faunas of particular oceanic realms that at times invaded European epicontinental basins and at the same or, more probably, at other times invaded inlets to Appalachian troughs on the western side of the sea. Under the belief that these invasions occurred mostly at alternating intervals on the two sides of the Atlantic—in other words, when emergent conditions were prevailing on the other side—it follows that the sequence of beds and faunas in any one of the areas in which deposits of Ordovician waters that invaded from, say, the Middle Atlantic sea occur can represent only

[24] Raymond, P. E., Mus. Comp. Zoöl. Bull., vol. 70, pp. 300–309, 1928.

a part, and in Europe usually only a small part, of the total time involved. This conclusion applies to the whole of Ordovician time and to invasions of very different northern and southern faunas as well as those that were at home in the Middle Atlantic. Europe, particularly northern Europe, seems to have only graptolite-bearing shales of Athens age to represent the great accumulation of marine deposits included in the Blount group in east Tennessee and southwestern Virginia. Middle Chazyan seems to be represented in the Girvan District of Scotland but can not be positively recognized elsewhere in Europe. The *Orthoceras* limestone of Norway, Sweden, and the Baltic region may correspond to our Lower Chazyan, but, for reasons than can not be readily given at this time, I am inclined to correlate it with some part or parts of our Buffalo River series. Should this belief be substantiated there would be little or nothing left in Europe to set opposite our Lower Chazyan. And so it goes. North America has many Lower Paleozoic formations that at best are weakly represented by sedimentary marine deposits in Europe, whereas those in Europe seem in most cases not strictly correlatable with ours. Their time relations seem to interfinger.

Another important factor that may be largely responsible for some of our difficulties in understanding and properly correlating European formations with those in America is the probability that the prevailing correlations that are carried from one to another of of the European exposures of Lower Paleozoic deposits are seldom strictly correct and often decidedly in error. In America we have proved that because of oscillation of the surface of the continent and the shallowness of the marine invasions the successive deposits in the varying Appalachian troughs and basins and in the broader basins of the interior areas are but seldom on the same stratigraphic plane. In other words, the bodies of water in which the deposits were made were patchy and often shifted from one negative area to another, thus being much less extensive at any particular time than was believed formerly. Most probably very similar conditions obtained in Europe also. Indeed, after seeing most of the Scandinavian and British exposures of early Paleozoic rocks, I am thoroughly convinced that the epicontinental seas in which they were laid down were localized and shifted about from time to time in essentially like manner and frequency as we have every reason to believe they were in America. Naturally, then, the sequences of deposits and of the times represented by them in each of the several areas in which negative tendencies are dominant vary more or less from place to place. If the European geologists in studying their Paleozoic deposits will stress differentiation of the beds and fossils of different basins, rather than continue to emphasize their points of

similarity, information regarding the geological history of their several countries will proceed to grow more rapidly than it has in the past 50 years.

Discussion of relative amounts and rates of deposition of Ordovician formations.—It has been suggested to me in recent years that the great thicknesses attained by many of the Paleozoic formations in the southern half of the Appalachian geosyncline indicate a more rapid rate of deposition there than in other areas that received much thinner sequences of deposits during the same geologic periods. But I see no valid reasons for believing this. In my opinion the difference in this respect between them is not so much in the rate of deposition during times of submergence as in the relative frequency and duration of such times. For instance, the 2,000–4,000 feet of calcareous shale and limestone that commonly make up the Athens formation required a long time to lay down; and in my estimation they were laid down no faster than were similar but much thinner beds in the Mississippi and Ohio valleys. The process of deposition in the latter was more often interrupted and, between the interruptions, of shorter duration; but during the times when it was going on the average rate at which the sediments were laid down was not much slower than in the case of the Athens. Of and in these, doubtless, the average rate to the foot was much faster than in most other places. But in those places where sandstones enter to any considerable amount into the process of Athens deposition, as to the east of Abingdon, Va., the thickness of the formation increases correspondingly to as much as 10,000 feet or possibly much more.

This general statement is made in full recognition of the rather obvious fact that whatever the kind of marine deposit, be it mainly or wholly of limestone or shale or sandstone, local conditions must have affected and caused variations in the rate of deposition, whether inference ascribes them to lack or uncommon availability of clastic material or to relative deeps or to deposition in shallow basins or troughs in which interruption of the process was likely to occur frequently; and at times the interruptions persisted through long periods. Thus, only a few miles west of the thickest development of the Blount formations in east Tennessee and southwestern Virginia they pinch out completely, their place in the sequence of formations being in a tight contact between Stones River and Lowville limestones that remain in contact to the Mississippi River and contain wholly distinct faunas of southern and not middle or north Atlantic origin. Moreover, the Stones River wedges out eastwardly beneath the Blount, and its lower formations interfinger in the same direction with Lower and Middle Chazyan formations. The Lowville, on the other hand, extends far eastward over the top of

the highest of the Blount formations. There can be, therefore, no question concerning the post-Middle Chazyan and pre-Mohawkian age of the *Telephus*-bearing beds of the Blount group whose relations to formations with similar fossils in southeastern Canada and Europe we are seeking to establish.

Blount faunas differ from similar faunas elsewhere.—The formations of the Blount group being confined in the Appalachian Valley to troughs with sediments of this age pinching out not only to the west but also in northward direction before reaching the southern boundary of Maryland, there is, as already mentioned, no direct connection between them and Mystic in the southwestern corner of Quebec Province, where highly fossiliferous bowlders of a particular kind contain *Telephus mysticensis* as one of nearly a hundred mostly undescribed species of the Atlantic fauna of its time. Of these many and varied kinds of fossils none seems strictly identifiable with any of their congeners in Blount formations to the south; and a considerable percentage of the Mystic bowlder fauna has no close relatives in Virginia, Tennessee, or Alabama. A few of the brachiopods, especially the species of *Strophomena?* and *Sowerbyella*, which always are difficult to classify, may on final comparison with Whitesburg limestone species prove insufficiently marked by peculiarities to warrant their separation under distinct names. A few of the trilobites also are closely allied to southern Appalachian species, and others are very near or the same as Newfoundland species. In fact Raymond[25] indentified some of them with both their southern and Newfoundland allies. Provisionally, I am willing to accept Raymond's judgment regarding most of the latter instances, but in the other cases, after making direct comparisons of Mystic and Newfoundland specimens with their nearest southern relatives, I must question the validity of his opinion. The observed differences, at least as regards the trilobites, seem in every case as great as those which distinguish the American species from their European allies and which in every case he regarded as demanding specific recognition.

Reason for observed difference in faunas.—Now, however similar in general aspect these northern and southern Appalachian faunas may be, why do they contain so few specific identities? I think it is because the beds in which they occur are not strictly of the same ages. In other words, those in the St. Lawrence trough were deposited at times when that part of the geosyncline sank beneath sea level and when its southern part stood above that level. This is not a new and unheard-of conception but merely a new application of views thoroughly discussed and abundantly illustrated by examples

[25] Raymond, P. E., Mus. Comp. Zoöl. Bull., vol. 67, No. 1, 1925.

nearly 20 years ago in my "Revision of the Paleozoic System"[26] under the general designation of continental and local "tilting" and "warping." Much was known even then about the north-south and east-west tilting of the only slightly deformed interior area of the continent, but we learn of new instances almost every year. We knew something also of the similar movements in the Appalachian region, but in this much less stable geosynclinal region the new applications of the theory have accumulated faster than we can adequately assimilate and adapt them to the general scheme. A recently published paper by Butts[27] gives a fair but incomplete statement of the present status of Appalachian Valley stratigraphy and of the frequent warping and tilting and consequent shifting of land and water areas to which this region was subjected during most of the Paleozoic periods.

Time required to effect observed modifications of faunas now available.—If my conception of the age relations of those formations in the southern and northeastern thirds of the Appalachian geosyncline and, on the other side of the Atlantic, in Scotland, Norway, Sweden, and Bohemia that contain fossil remains of the Ordovician middle Atlantic faunal realm is correct it obviously greatly expands our previous estimate of the aggregate volume of the marine sediments of this period and also of the time required to deposit them. However, even this expansion fails to cover all the missing links of the whole span of time involved, for it does not take into account the probable inaccessibly recorded but logically inferable intervals between the alternating and very slowly effected north-south and east-west tiltings during which the waters of the Atlantic were confined to the oceanic basin between the continents. At those times the continents were too completely emerged to permit marine deposition in the surficial troughs and basins that at other times suffered Atlantic invasion and sedimentation. Under my conception these additional times are required to produce the structural modifications that distinguish the successively evolved stages or "species" that are preserved in the accessible stratigraphic record which, of course, is everywhere more or less fragmentary. Natural evolution, as it seems to me, was always an exceedingly slow process. Supposed or suggested fossil instances of saltatory changes usually prove to have been initiated long before. As a rule the production of the results that are being gradually uncovered by paleontological investigations required more and ever more time than was granted by preceding interpreters of geologic history. Thanks to the physicists and chemists all the time we may require seems now available.

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[26] Gool. Soc. America Bull., vol. 22, p. 291–680, 1911.

[27] Butts, Charles, Variations in Appalachian stratigraphy, Wash. Acad. Sci. Journ., vol. 18, No. 13, pp. 357–380.

ORIGIN AND AGES OF POST-BLOUNT FAUNAS IN NORTH AMERICA AND EUROPE

Post-Blount formations in America.—It is a well established fact that the east Tennessee part of the Appalachian Valley tract contains no Ordovician deposits with fossils of either the middle or north Atlantic realms that are younger than the Ottosee. Those that succeed the Ottosee here are all extensions of Ohio, Kentucky, and central Tennessee formations with faunas that invaded from the south. But south of Tennessee, in the Cahaba Valley, in Alabama,[28] there is a limestone formation, the Little Oak, with a maximum thickness of at least 500 feet, that pinches out in southward direction near Siluria and also in a northerly direction not far beyond Odenville. Near Siluria its thinned southern edge rests on the similarly attenuated extremity of the Athens, but greater thicknesses of both occur in the belt between Shelby and Talladega Springs. At and to the north of Pelham the Little Oak rests on the Lenoir, and over most of its outcrop its top is in contact with Devonian or Mississippian deposits.

The Little Oak fauna, even considering only its generic character, has little in common with any of the Blount faunas except that of the Holston. But it does exhibit a general and in part close resemblance to the Lenoir fauna and through that with the Middle Chazyan fauna in the Champlain Valley.

South of Harrisburg, Pa., and on through Maryland into Virginia, as far at least as Lexington, there is another limestone formation, named from Chambersburg, Pa., that contains a number of faunules that comprise a considerable percentage of species whose relatives are known elsewhere in America mainly or only in the Little Oak, Ottosee, and Lenoir formations. In southern Pennsylvania the Chambersburg rests on the Lowville, which fixes its age as younger than Lower Black River. But at Lexington, Va., beds that are unquestionaly a largely traced southward extension of it rest on the limestone facies of the Athens. At both places—also at Strasburg and other localities in northern Virginia and in Maryland—the Chambersburg is followed by Martinsburg shale which begins with the shaly facies of the Lower Trenton. Locally, however, as at Chambersburg, a few feet of shaly limestone, with recurrent middle Atlantic trilobites, intervene.

We have then two post-Blount formations in the Appalachian Valley—one under the Lowville, the other over it—the faunas of which agree in general aspect and in containing at least a few generic types that are believed to be indigenes of the middle Atlantic realm whose purer Ordovician fauna is so well represented in the *Telephus*-bear-

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[28] See Butts, Charles, Geology of Alabama, p. 112, 1926.

ing formations in eastern North America and Europe. But the greater part of both of these faunas is so much more like that of the Lenoir and those of the Lower and Middle Chazy of the Champlain and St. Lawrence valleys that common origin for all of them seems highly probable. But where the bulk of these Middle Chazyan, Little Oak, and Chambersburg faunas originated and by what paths they reached Pennsylvania, Virginia, and Alabama can as yet be explained only by conjecture. Some of the Champlain Chazy species suggest a northern origin, though hardly Arctic, and it may be that they migrated from there by way of the Champlain Valley to the west side of the middle Atlantic basin. Or they may have gotten to inland troughs that are now buried beneath the Coastal Plain south of New York in which they attained and for some time maintained a foothold. The available evidence suggests further that the Chambersburg invasion of the Appalachian Valley came from these more eastern, probably Piedmont and subcoastal plain troughs.

Origin of Trenton and late Black River faunas.—In this connection I wish to call attention also to the Trenton faunas of Ontario, New York, New Jersey and Pennsylvania, and to make the general statement that all but one of these faunas is very different from those of the corresponding Trenton group of formations in Tennessee and Kentucky. Excepting the crinoid and cystid fauna that is held in common by the first or Curdsville limestone formation of the Trenton group in Kentucky and the Hull limestone, which is the second of the Trenton formations in Ontario, the Trenton faunas in Kentucky and Tennessee comprise many clearly indicated progenitors of the succeeding Cincinnatian faunas in the same States and like these doubtless invaded the continent from the south. On the contrary, the New York and Ontario Trenton faunas—which not only began their epicontinental record earlier (that is, with the Rockland), but extended their geographical range from Ontario westward to Minnesota and from there southward to the flanks of the Arbuckle Mountains in Oklahoma—these must have invaded the continent from the northeast or north. And an essentially similar conclusion is forced on us regarding the origin of the late Black River Decorah faunas that underlie the Trenton formations in the Mississippi Valley and Ontario. The northern origin of the Decorah faunas is inferred and reasonably proved by the total absence south of central Kentucky of beds that, if present, doubtless would contain them. On the other hand, they are present in most if not all of the exposures of rocks of similar age to the north in Canada. Still more convincing is the fact that comparison of Decorah and early Trenton (Prosser) faunas in the Upper Mississippi Valley with Baltic Ordovician faunas discloses many generic similarities, and particularly among

the Bryozoa,[29] a considerable number of specific identities. In view of these otherwise inexplicable facts I see no way to escape the conviction that these Baltic and American faunas originated in and at opportune times migrated from the same oceanic basin; and that basin must have been in either the Arctic or the North Atlantic Sea.

Another point to be brought out is the genetic connection between these Decorah and New York-Ontario Trenton faunas, on the one hand, and the already discussed and mostly older Chambersburg, Little Oak, Ottosee, Holston, and Lenoir faunas of the southern Appalachian region and of the Chazyan in the Champlain Valley, on the other. Whatever the modifications and special peculiarities that pertain to and enable us to recognize and distinguish each of these faunas from the others there still remain many genetic threads that are common to them all and indicative of a more or less strongly manifested common source.

But the depositional data pertaining to this hypothetical North Atlantic faunal province are as yet too insufficiently known to be presented as anything better than more or less vague clues to an interesting chapter in the history of Ordovician oscillations and marine faunal migrations. Accordingly, my confidence in the foregoing facts and suggested inferences goes no further than the strong belief that a distinct marine faunal province existed in the North Atlantic region during a considerable part of Paleozoic time. Also that the Champlain Chazyan, the Little Oak of Alabama, the Chambersburg of Pennsylvania, Maryland, and Virginia, the Lenoir and parts of the Blount group of Tennessee, Alabama, and Virginia, the eastern and Upper Mississippi Valley Decorah and Trenton formations, the deposits in the Baltic province, and the typical Stinchar of southwestern Scotland all participated in its history.

POST-CHAZYAN—PROBABLY EARLY SILURIAN—FORMATIONS IN EUROPE

Generalized comments on the Ordovician-Silurian boundary.—A problem in stratigraphic correlation on which opinions differ very greatly concerns the proper classification of such European formations as the Drummuck in the Girvan District in southwestern Scotland,[30] the Keisley limestone in northwestern England, the Leptaena limestone in Sweden, and the Lyckholm and Borkholm formations in Estonia. Reed identifies some of the Drummock trilobites with Keisley species and some of the same and other species of the Keisley with characteristic members of the Leptaena limestone fauna; and there is general agreement among British and Scandinavian geolo-

[29] Bassler, R. S., Early Paleozoic Bryozoa of the Baltic Provinces: U. S. Nat. Mus. Bull. 77, 1911.

[30] See also notes on the "Craighead" limestone, p. 84.

gists in correlating the mentioned formations with each other and also, though somewhat more loosely, with the Lyckholm and Borkholm of the Baltic region. They agree, further, in referring them all to the upper part of the Ordovician system. Perhaps, and I may even say probably, they are right in holding to this opinion so long as the base of the Llandovery in Wales, the Rastritesskiffer in Sweden, and the Addifir in Estonia are insisted on as marking the base of the succeeding system. But is their apparently still uncompromising attitude on this question warranted by the changing needs of a growing science? I have thought and still think it is not.

On various occasions, but especially in my most recent paper on the Ordovician-Silurian boundary,[31] I have cited and discussed many facts that show that this is not the most natural nor the most widely recognizable boundary nor the one that marks the beginning of physical conditions that distinguish the new period and sets it apart from the preceding. Besides, the contact of the Llandovery with the Bala and Caradoc, which Lapworth in 1879 designated as the boundary between his newly proposed Ordovician and the restricted Silurian system of Murchison, does not correspond to the boundary between the Champlain and Ontario divisions of the New York system that were proposed by Emmons and his associates on the New York Survey in 1842 and which since then have been generally abandoned in favor of the no better defined and, in their present significance, much younger British terms. I am not a sufficiently strict adherent to the law of priority to object to this usurpation of terms, but I do object to the abandonment of those features of the original New York classification that in my opinion give a better and more natural classification of the concerned parts of geological history.

The advantage of the original definition of the term Ontario (or Ontarian as Dana amended it in 1890) over the definition of the restricted Silurian system that now prevails rather generally in Europe lies in the fact that both its lower and upper boundaries as delimited by Emmons in 1842 are more consistent with nature's definition [32] of the period to which it was applied than is Lapworth's redefinition of the term Silurian that has been adopted by most American geologists since 1879 without adequate investigation of its fitness as a major term in the classification of American formations. Emmons defined the "Ontario group" as overlying the Champlain group and underlying the Helderberg series and as including the Manlius at the top and the Medina sandstone at the base. This definition accords precisely with the system of rocks in America for

[31] Relative values of criteria used in drawing the Ordovician-Silurian boundary. Geol. Soc. America Bull., vol. 37, pp. 279–348, 1926.

[32] Ulrich, E. O., idem, p. 326, 1926.

which I have used the British term Silurian since 1910. But it does not agree in either its base or its top with Lapworth's Silurian system. As defined by him the Silurian system in Britain comprises the "strata comprehended between the base of the *Old Red sandstone* (Devonian system) and that of the *Lower Llandovery*," which differs considerably from the "Ontario group" of Emmons, the original limits of which were retained without modification when most of us discarded its American designation and adopted Silurian in its place. Lapworth's definition includes beds corresponding to our Helderbergian series, which all American geologists now refer to the base of the Devonian; and it excludes and refers to the Ordivician all beds in Great Britain that are older than the base of our Clinton, whereas in American practice without exception the Silurian includes the whole or at least the upper half of the underlying Medinan series.

The differences between the British and American practice in drawing the top and bottom limits of the Silurian arise in part from differences in methods. The former inclines, at least in these cases, to the practice of beginning a system at a stratigraphic break that immediately underlies the first well-established change from the dominant character of the fauna of the preceding period to that of the succeeding period. The latter inclines rather to the practice of begining the new system with the first diastrophically well marked introduction of the new fauna. But, for obvious reasons—particularly as regards difference or likeness in source of the compared faunas and the greatly varying dates at which marine deposition of a given period began or ceased in the numerous epicontinental basins—the degree of difference in the general aspect of the faunas in beds that are contiguous yet of different periods depends very largely on only locally operating factors. Thus, if the faunas of such adjoining beds invaded from the same oceanic realm the younger of the two is likely to comprise a strongly dominant part that is made up of direct descendents of the older fauna; if they invaded from different realms then the difference between the two is much greater and often complete.

Even in different parts of the same continental province the first deposit of a given period may be shown by its fossils to be either much younger or older than is the first of the period in other parts. In some places only the lower series of a system may be represented, in another only its middle, and this may then be followed by the closing stage. Again, in some places only the closing series is represented whereas in other places beds of the closing series are in contact with deposits of the lowest series. Finally, there are a few places where fuller sequences with a thick middle series are found.

All these varying sequences of the deposits of a given period—and the Silurian as developed in southeastern North America is no exception—may occur in a distance of 100 to 200 miles. It makes a lot of difference, therefore, in the final systemic classification of formational units where the type section of a system, series, or group may be. And in the case of the Silurian, provided world-wide application of divisions of the stratigraphic column of its grade is contemplated, I see no reasonable ground for insisting that the system must be limited below by the base of the Llandovery. As we know from the work of Jones and others; and as I know from personal observations in the concerned areas, the base of the Llandovery in Wales and Shropshire is unconformable by overlap so that the stratigraphic significance of the hiatus between it and the underlying Ordovician formation varies from place to place. Doubtless if this hiatus could be pursued to its minimum in Britain the unconformity would pass beneath beds that are not present in Wales and Shropshire and which, despite their inherited Ordovician faunal types, would be more naturally classified as early Silurian than late Ordovician.

Age of the Keisley limestone and other European formations.—In 1926,[33] in discussing the persistence of important Ordovician generic types of the Middle Atlantic fauna to apparently early Silurian time in certain European formations, I pointed out that the Drummuck of Scotland and the Keisley of England, also their generally accepted Scandinavian and Baltic equivalents, all contain the first appearances in their respective countries of genera that occur in North America only *above* Richmond in beds that are universally admitted to be of Silurian age. A composite list of the better known of these genera includes, of brachiopods, *Atrypa*, *Atrypina*, *Bilobites*, *Chonetes*, *Dictyonella*, *Meristella*, *Mimulus* (or *Streptis*), *Rhipidodomella*, *Schuchertella*, *Stropheodonta*, *Strophonella*, *Whitfieldella*, and varieties of *Dalmanella elegantula* and *Rhynchotreta cuneata;* and of trilobites, *Cheirurus* s. s., *Deiophon*, *Dicranogmus*, *Dicranopeltis*, *Lichas* s. s., *Arctinurus*, *Staurocephalus*, and *Trochurus*. In my opinion, none of these genera originated in the middle Atlantic realm. They are migrants from the southern Atlantic basin or from some other marine breeding ground that lay to the south of the present Gulf of Mexico and which supplied the greater part of most of the Silurian faunas that invaded America through the Mississippi embayment.

A fact of considerable importance in this connection—important because it supplements and greatly strengthens the previously available evidence on which I based my view as to the time when these

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[33] Geol. Soc. America Bull., vol. 37, p. 322.

southern genera appeared in the temperate zone of the northern hemisphere—was noted in looking over Twenhofel's recently published work on the Geology of Anticosti Island. In this report Twenhofel illustrates and very briefly describes four Lichadidæ, three of them new and all referred to the genus *Amphilichas.* The oldest of these, *A. borealis*, new species, founded on a cranidium collected from the upper half of the English Head formation, is a normal *Amphilichas* and much closer to other American Richmond species than to the Swedish *A. dalecarlicus* with which Twenhofel compares it. However, the other three Anticosti species belong to two of the genera above listed as Silurian migrants from the south. One, *A. shallopensis* Twenhofel, from zone 9 of the Jupiter River formation, is a typical *Lichas;* the other two—*A. canadensis* (Billings), from the lower half of the Jupiter River, and *A. arenaceus* Twenhofel, from the top bed of the underlying Gun River formation—are based on such characteristic pygidia that I refer them without hesitition to *Arctinurus.* The presence of species of *Lichas* s.s. and *Arctinurus* in Anticosti and their restriction here to zones that all agree are of the age of the Clinton are facts that for three reasons are regarded as of particular significance in the determination of the age relations of the Keisley and related north European deposits to formations of the American Paleozioc sequence. First, because unquestioned Richmond formations (English Head and Vaureal) are succeeded in the Anticosti section by two formations (Ellis Bay and Becsie) that I regard as representing the Upper Medina or Alexandria group of New York and the Mississippi Valley and which in turn are succeeded by the Gun River and Jupiter River formations, which contain the mentioned species of *Lichas* and *Arctinurus* and of which the latter and at least the upper part of the former are undeniably of Lower Clinton age. The second reason is the well-known fact that the faunas of the Clinton part of the Anticosti section exhibit closer relations to British Llandovery and Wenlock faunas than any other Silurian section in North America. The third reason is that in Europe as in America the above listed genera of brachiopods and trilobites that have been set down by British and most European geologists as common to Ordovician and Silurian deposits in their countries attain their best development in Upper Clinton and later Niagaran deposits; and they do not occur at all in America beneath the top of the Medina nor in Britain and Sweden beneath the formations that I claim would be more naturally classified as early Silurian than late Ordovician.

The misunderstandings that have so long beclouded the problem of the proper position of the Ordovician-Silurian boundary have

arisen mainly from the fact that in the Drummuck and Keisley of Britain, the Leptaena limestone of Sweden, and to lesser extent in the Borkholm of Estonia the, as I think, really Silurian species of the above-listed genera of brachiopods and trilobites are associated with a predominating number of direct descendants of preceding stages of the middle Atlantic fauna found in underlying really Ordovician formations in the same countries. Because of the dominance of these persisting, "residual" Ordovician elements—among them even a species of *Telephus*—it is only to be expected that in following the formerly prevailing but now thoroughly discredited method of determining the age of a formation by the relative dominance of generic and specific similarities in compared faunas geologists generally assigned these legitimately debatable formations to the Ordovician. However, in doing so they caused much regrettable confusion in stratigraphic correlation and great but I hope only temporary impairment of the indexical value of more than 30 genera of fossils. In making this statement I do not wish to be understood as implying that the vertical range of these generic types is fixed and chronologically the same the world over and that they did not exist *somewhere* in recognizable form either earlier or to later dates than the information now available indicates. On the contrary, I feel certain that the 30 genera just referred to originated and slowly developed their characteristics in southern marine realms, the Silurian life of which we know now only through the little we can gather from the migrants that reached and left their remains in epicontinental basins of the northern hemisphere.

Silurian age of the Leptaena limestone proved by graptolites.—Facts that give me much satisfaction because they will be accepted generally by European geologists as proving the Silurian age of the Upper *Leptaena* (Kallholn) limestone and its equivalents or near equivalents elsewhere, and also of the underlying Dalmanites shale have recently been brought out by Troedsson and Roswall who found that black shale with Middle Birkhill graptolites are really interbedded with the reefy deposits of the former at Kallholn, Dalarna, Sweden. So much of the battle seems thus to have been won. But why not go a step or two further down in the section and drop the Ordovician-Silurian boundary to some still lower diastrophically marked plane that would more nearly correspond to the naturally defined and very widely recognizable stratigraphic break in the American section? For instance, to the base of the *Staurocephalus* zone; or even to the bottom of the "Trinucleus beds?" The latter, like the Middle Richmond Sylvan shale in Oklahoma, contains a species of *Dicellograptus* that is referred to the British Upper Hartfell *D. complanatus;* and this is not by any means the only fossil

that may be said to suggest that the *Trinucleus* beds are of early Richmond (i. e., post Maysville) age.

Troedsson, in the stratigraphic part of his 1928 report on the Middle and Upper Ordovician faunas of northern Greenland, devotes many pages to the discussion of this problem. But his conclusions, at least in so far as they are concerned with the faunas of the American Richmond and Mohawkian formations, are largely based on erroneous or insufficiently digested data. In consequence the conclusions are usually at least open to question and in most cases definitely negatived by more competent modern evidence. Unfortunately most of the latter evidence is as yet unpublished; and it is impossible to settle the questions involved in the proper classification of the Arctic Ordovician and early Silurian formations before the old data have been either substantiated or corrected and carefully studied in the light of the new evidence. Although much of this work has been done considerably more remains to do before I shall feel ready to record final conclusions.

Inadequacy of formerly prevailing methods of correlation.—So long as we depended indiscriminately on predominance of trend of evidence determined by matching entire faunas rather than on precise identification of particular species in both intra- and interprovincial correlations, and so long as we followed Suess in explaining the observed evidences of Paleozoic and later displacements of the strandline as essentially eustatic, there really was but little or no chance to achieve definiteness and verity in details in determining the age relations of disconnected formations, whether their separation is ocean wide or relatively limited. I am referring particularly to formations in regions that as a rule are affected differentially by the slowly but constantly proceeding undulatory movements of the surface of the lithosphere.

The rudiments of these revolutionary ideas entered my mind when, nearly 30 years ago, I noted the rather unsatisfactory results attained in the endeavor to correlate the Ordovician formations in America by data obtained during the course of my paleontological work in Minnesota.[34] Casting about for some possibly more definite physical means of checking the fossil evidence the rather obvious relation of the processes of diastrophism to the then new Dutton theory of isostasy seemed to offer a promising field for investigation. Soon this promise gave way to greater and since then constantly growing con-

[34] No more conscientious or more thoroughly finished effort to correlate formations by matching entire faunas and also no greater failure to achieve true solutions, particularly as regards the lower faunal horizons, is to be found in geological literature than my 1896 attempt to correlate the Ordovician formations in Minnesota with those in Kentucky, Tennessee, and New York. (See Minnesota Geol. Survey, Final Rept., vol. 3, pt. 2, pp. LXXXIII–CXXII.) What a help some of the ideas here briefly discussed would have been.

fidence in the faunal and stratigraphic criteria of diastrophism, which in my definition of the term includes evidence of any movement of the surface of the earth that occasioned displacement of the marine strandline and resulted in generic modifications of the preceding composition of faunas and floras or in their local extinction or complete replacement by faunas derived from other sources. My confidence has grown constantly also in the consequent paleontological principle that the more or less abrupt introduction of new generic types in epicontinental marine deposits, especially if the new elements were derived from a previously excluded faunal realm, is a far more reliable criterion in fixing stratigraphic boundaries and in determining their taxonomic significance than is the general or composite aspect of the fauna in which these foreign constituents occur. The importance of these invasions of foreign elements—whether they appear but once or repeatedly at intervals in a given section—lies in the probable fact that some diastrophic movement, the results of which included submergence of a previously excluding barrier, had occurred at times shortly preceding their advent.

That my confidence in these views has not been misplaced is proved by the great success that has attended their application in American stratigraphic problems. As they served very well in these it seemed probable that they would serve equally well in the apparently quite similar European cases in question. Accordingly, in the paper on the Ordovician-Silurian boundary already cited I advocated removal of the Drummuck, Keisley, Upper Leptaena, and other north European formations generally regarded as of approximately like age from the lower side of the line to above it. Obviously, it is with considerable interest that I await the reaction of European opinion to my proposal. For two reasons the points mainly at issue are presented here again, though more briefly and viewed from somewhat different angles; first, because the opportunity to say what I hope may be my last word on the subject is at hand; and, second, because the facts mentioned in its discussion have a decided bearing also on my contention respecting the generic persistence of the indigenous life of the middle Atlantic realm—or, indeed, of any of the centers of faunal development and dispersal—which I find to be much greater than anyone believed heretofore. It has been also the most pregnant though perhaps least suspected cause of error and general confusion in correlating formations of different provinces.

General similarity of fossil contents without precisely identified closely drawn species certainly does not establish contemporaneity of the compared deposits. On the contrary, it usually indicates difference in age. Moreover, it is practically impossible to correctly estimate the chronologic significance of such differences except when

discovery of overlaps of concerned formations furnishes the proof of at least a part of its possibly very great importance. No more strikingly illuminating example occurs to me that the slight difference in the faunas of the Lebanon and Lowville limestones which are in contact in central Tennessee but separated in east Tennessee by a maximum of 8,000 to 10,000 feet of limestone and shale deposits with entirely different fossils. To further illustrate the uncertainties that generic matching of fossil faunas may entail I would mention the supposititious but easly conceivable and quite possibly actual contemporaneity of marine deposits with entirely different fossils. Such a case could be explained only after we had learned that one of the faunas had originated in and invaded from, say the Pacific, the other in and from the Atlantic, and that both are directly overlain and underlain—without sign of discontinuity of deposition—by the same pair of formations.

RECENT PROGRESS IN AMERICAN STRATIGRAPHY

Old and new data indicating persistence of indigenous faunas.—The truth of preceding statements regarding the indigenous persistence of faunal assemblages is clearly shown by previously published information concerning the now undisputed recurrences of the Spergen fauna in early, middle, and late Mississippian formations. Interest in this case has been revived and emphasized by two still younger recurrences of the same dwarfed fauna in Pennsylvania formations, the highest only recently discovered by Charles Ryniker in Oklahoma. Apparently these recurring hordes of small fossils are really to be regarded as long persisting and very slowly modifying dwarfed descendants of a far southern Middle Devonian fauna of which normally sized individuals reached New York State already in Hamilton time. Whether this inferred derivation of the diminutive molluscan Spergen fauna is correct or not there certainly is less reason for considering most of its constituents as dwarfed forms of species of the same classes found in intervening Mississippian and Pennsylvanian beds. The latter probably were produced in a nearer breeding ground that supplied, or at least contributed to, most of the Paleozoic faunas that invaded America from the south through the Mississippi embayment. Another alternating sequence of invasions from two distinct faunal centers through the same Lower Mississippi entrance comprises the simulating late Trenton Catheys fauna, the Fairview fauna, and, finally, the early Richmond Arnheim fauna, on the one hand, and the preceding Trenton and intervening Cincinnatian faunas on the other. The latter also exhibit a more marked general resemblance to each other than to the immediately succeeding and preceding faunas of the first set. Many other such instances of

more or less widely spaced invasions of but slightly modified stages in the evolution of the life history of a particular marine breeding ground alternating in the same sections with similarly related emanations from another source might be cited. However, those mentioned sufficiently illustrate the general idea I am intending to convey. Besides, some of them—like the notable cases of the Utica and the Maquoketa that concern graptolites and other thin-shelled remains usually found in Ordovician and Silurian deposits of black shale—require too much explaining. Therefore, all I think worth adding is that in all the mentioned cases the alternating changes in the character of the faunas are never complete. Evidently the invasions from the farther source in passing through some part of the nearer source joined the usually smaller contribution of the latter. Then, when the supply from the more distant source was reduced or completely cut off some of its species that had gained a foothold in the nearer source were thus included in its subsequent contributions. It is to be noted further that when these changes occurred the ensuing invasion usually included also a few and sometimes many contributions from other previously excluded sources; and it is these entirely new migrants that constitute the most reliable and the most easily notable of its guide fossils.

Progress in middle western and Cordilleran regions.—Extremely interesting and important stratigraphic results have developed in the course of field and laboratory investigations of the character and geographic distribution of faunas and formations in Oklahoma. These relate particularly to demonstrations of early and middle Paleozoic surface undulations and consequent shiftings of the strandline on the flanks of the Arbuckle and Wichita uplifts in the south central part of the State. Comparison of numerous cross-sections shows that the sequence of formations on their flanks varies greatly and rapidly from place to place. And the faunal evidence, doing its part in the elucidation of the geological history of North America, shows that these areas suffered alternating invasions from the Pacific, Arctic, Atlantic, and southern sides of the continent during each of the Cambrian, Ozarkian, and Ordovician periods. Much of the doubt and misapprehension that has prevailed in Oklahoma stratigraphy, especially as regards relations to deposits in the adjoining States of Missouri and Arkansas, is being explained in orderly fashion by these discoveries. Each of the pre-Mississippian formations of preceding classifications is being divided on faunal and diastrophic criteria into two to six clearly distinguishable formations; and the locally extremely varying great sequence of limestone deposits that in Taff's classification is called Arbuckle limestone is split up into one Cambrian, six Ozarkian, and three

Canadian formations. In short, we are prepared to give an altogether new and very different account of Oklahoma stratigraphy that moreover throws much new light on the interpretation of geological events in other parts of the continent.

As details regarding the results of these studies will probably be published in the near future their further anticipation here seems undesirable. What has been said sufficiently indicates the progress that is being made in working out the broader aspects of the Paleozoic history of the middle part of the Mississippi Valley region. Great progress is being made also in the already much better known Upper Mississippi Valley region. The results of these investigations, which comprise much more detailed information regarding the paleontology of especially the Cambrian, Ozarkian, and Canadian deposits than is now available in published form, is also being prepared in collaboration with others for early publication. Nor are the results of continued investigations in the Cordilleran province that were begun by Walcott and inherited by Dr. Charles E. Resser and myself falling short of expectations. In fact, the stratigraphic and extremely abundant faunal data from all of these regions are being studied concurrently.

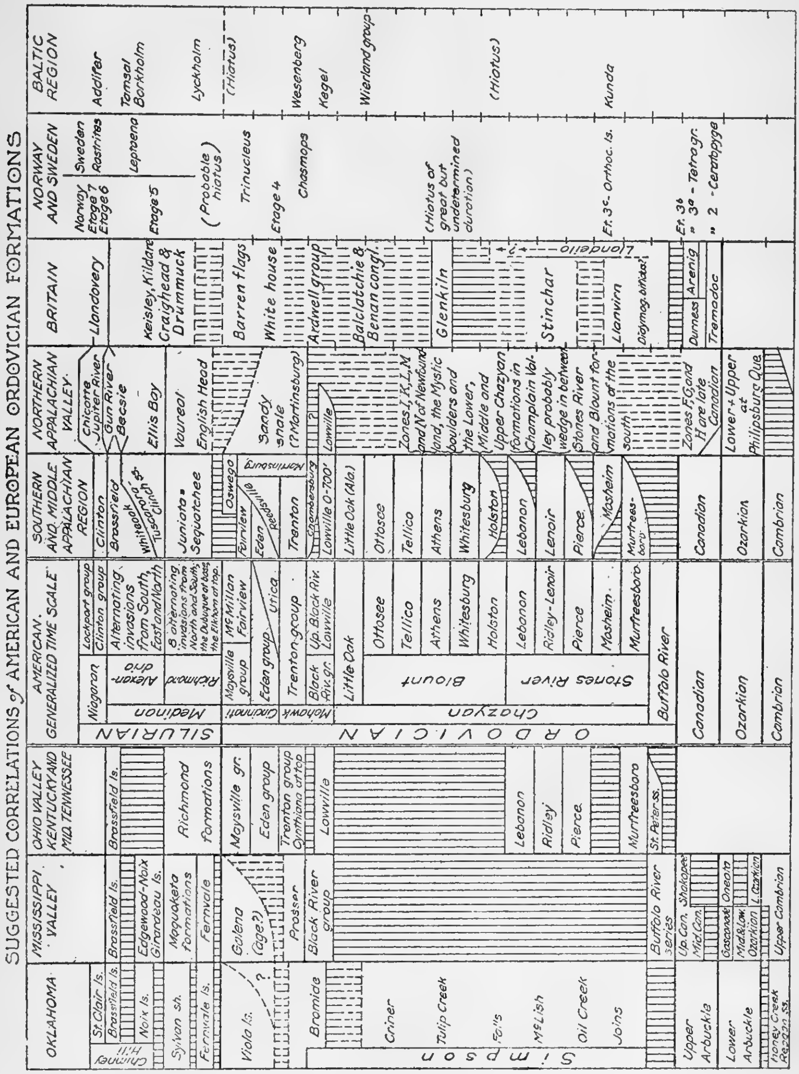
Finally, as regards the Appalachian region, the years of painstaking labor bestowed on it by Dr. Charles Butts are correcting, supplementing, and gradually filling in the details of work begun by me nearly 30 years ago and partly published in 1911. Hundreds of pages filled with notes on redefinitions of formations and new positions assigned to them in the correlation tables and detailed descriptions of sections and faunal lists, which had been written and submitted with the discussion of principles and criteria of stratigraphic correlation that was then published under the title Revision of the Paleozoic Systems, remain unpublished to this day. With the help of Dr. R. S. Bassler, who assisted me in the field during parts of the ten years mainly devoted to stratigraphic investigations in the Appalachian Valley, much of this neglected manuscript will be revised to meet present-day requirements and again submitted with subsequent observations for publication. In the meantime results of Doctor Butts' investigations in the southern end of the valley have been published by the United States Geological Survey in the Birmingham Folio and more fully in the volume published by the State on the Geology of Alabama (1922). During the past two years he has been engaged on the Virginia part of the valley. His work here is disclosing an astounding amount and variety of highly interesting and important details as regards the distribution of formational units, stratigraphic overlaps, and consequent local variations in the sequence of beds and the geologic structure of the area.

In a mental review of the accomplishments in American stratigraphy during the past 30 years the feature that impressed me more than any other is that in this short time the aggregate thickness of the Paleozoic rocks in America alone has been shown to be nearly three times as great as we thought it in 1898. Many thick formations that only 20 years ago were regarded as contemporaneous deposits have one after another proved to be of distinct ages; and when one had been traced over or under the other the contact between them still was broken; and when this contact had been traced to another supposed equivalent the latter was found to wedge into the break which opened often widely to receive it. However much our efforts to fill the gaps have been rewarded we seem to succeed only in dividing them into smaller breaks. And so, especially if views discussed on preceding pages are not wholly visionary, I realize perhaps more than any other that the task of building up the world sequence of epicontinental marine deposits is far from completed.

European geologists have not kept pace with us in recognizing the extremely oscillatory nature of marine invasions and ensuing deposition in epicontinental basins, nor have they discriminated and correlated their Paleozoic formations in accord with anything like our conception of small shallow seas that, in responding to frequent surface warpings, were largely or entirely withdrawn or shifted from one negative area to another. The older generation of geologists are not expected to take very kindly to such unsettling views, but the younger ones, in whose hands the future of the science lies, will, I am sure, at least consider and try them out, because they promise a rich reward.

At present, detailed interprovincial stratigraphic correlations, referring particularly to lower and middle Paleozoic marine formations on the two sides of the Atlantic, are shrouded in uncertainties. These are occasioned partly by neglect of other than fossil testimony but mainly by lack of strictly and specifically comparable faunal evidence. When the generic aspects of such evidence seemed to point toward a reasonable conclusion the hope of success, at least as regards my own efforts, has been nearly always negatived by associated things of contrary trend. I must, therefore, frankly confess that I do not know how certain British formations and the usually smaller Scandinavian and Baltic units will finally fit into the greater American stratigraphic record, or how they will assist in the perhaps impossible task of completing the geological time scale of the world. I fear, too, that my present effort has succeeded rather more in complicating the issues than in simplifying and deciding them. Let us hope that it may prove the darkness that precedes the dawn. Time will tell, for it will bring the fuller and truer knowledge of the fossil faunas

and their origin and evolution and of the physical changes that caused their local advent and extinction or permitted intermigration of diversely originating types that is needed to dispel prevailing obscurities.



DISCUSSION OF CORRELATION TABLE

Basis of the generalized time scale.—The column giving the generalized time scale in the accompanying correlation table is built up of stratigraphic units of thoroughly determined age relations in different parts of eastern North America. The Silurian part of the

column is taken from the Mississippi and Ohio Valleys and the Ordovician part from the southern Appalachian Valley and central Tennessee except the Buffalo River series, which is best developed in northern Arkansas. As will be observed, only the Chazyan part of the column is divided into units of formational rank, this being the part that is mainly concerned with questions discussed in this paper. Besides, and however detailed the correlations of American Ordovician and Silurian formations may be, we can as yet do no better in correlating European formations of these periods than to suggest more or less indefinitely located positions for them in one or another of our series or groups.

Though this column is called a time scale it should not be assumed that even its Ordovician part accounts for all of the time included in this period. In fact it accounts only for those subordinate parts of the accesible depositional record that was laid down in American epicontinental basins; and of these only those whose sequential relations have been estabilshed. As most if not all of the named minor units of the scale are separated from each other by stratigraphic breaks of undetermined time significance it follows that these depositionally unrecorded intervals, at least, are not accounted for. Doubtless some of these intervals are represented, probably only in part, by deposits in other areas of the North American Continent, but these could not be used in constructing the scale because their relations to those found in the southern Appalachian, Ohio, and Mississippi Valleys are insufficiently understood; and we know even less about the correlation of the European and American Ordovician deposits. Finally, as suggested previously (p. 54), there may have been times when the continents on both sides of the Atlantic were so elevated above sea level that the basins in which Ordovician marine deposits are now accessible were completely drained. Obviously such times also are not accounted for. It follows, then, the "generalized time scale" of the chart is incomplete to these several extents and pretends to be nothing more than a temporary standard for comparison.

Perhaps I should call attention also to the fact that the correlations with formations in European countries differ considerably from those given in a similar table published by me only three years ago.[35] However, the changes occur mainly in the lower two-thirds of what I think should be included in the Ordovician system, which, as many know, I define differently from the original and even yet prevailing conception of that term. Briefly stated, my definition of the Ordovician system is based primarily on diastrophic criteria that in my

[35] Relative values of criteria used in drawing the Ordovician-Silurian boundary: Geol. Soc. America Bull., vol. 37, p. 329, 1926.

opinion demand elimination of formations from both the top and the base of this system as originally defined by Lapworth. The evidence on which these views are based, particularly those facts that concern the upper boundary of the system, are briefly discussed above and much more fully in the just cited Ordovician-Silurian boundary paper published in 1926. The evidence relating to the lower boundary was already rather thoroughly pointed out in my "Revision of the Paleozoic Systems" published in 1911, but some of it will again be presented with local details and in generally amplified form in a work on the Paleozoic formations in Oklahoma due to appear before the close of the present year.

Generalized comments on other columns of table.—Regarding the changes in correlating European and American formations that continued study of the extremely difficult problems in the past three years has indicated, I make no apologies. The innovations are presented as suggestions and not as final conclusions. They are based on theoretical considerations and reasonable inferences and probabilities that are not yet susceptible of satisfactory proof—and may never be. Still, they seem as well worth trying out as other not very dissimilar suggestions were that have been presented in the past twenty years and whose merits have in the meantime been fully established.

The probable bearing of the postulated differential character and slowness of the vertical movements of the surface of the earth on the correlation of formations in the more or less widely separated geological provinces covered by the table is indicated by the intermediate placing of many of the names of the formations in the several columns. However, I am not at all certain that the European and even some of the North American formations actually belong in the positions assigned to them in the chart. Any of these may belong a notch or two higher or lower in the time scale than is indicated by the present status and probable trend of the organic and physical evidence studied to date. But I do feel satisfied that the tentative arrangement presented in the chart is a nearer approximation to the facts in the several cases than any previous effort has attained.

Of extreme and commanding importance in working out the sequence of events and the great length of time involved in the geologic history of the Lower Paleozoic ages is the indisputable fact that so far as known the least incomplete depositional record of these ages occurs in America. I venture to say further that, so far as the stratigraphic correlation of the marine deposits of these ages in the several largely supplementing provinces in North America is concerned, the record of the frequently shifting Paleozoic epicontinental seas is also better understood than is the more epitomized and on the whole much less completely developed record found in European

countries. Let me not be misunderstood here. I have no wish to deny that the local developments of the fossil faunas in Bohemia, the Baltic region, Sweden, Norway, and, perhaps in less degree, also in Great Britain have been more thoroughly exploited and the results of their study published than in America. This admission applies particularly to the often extremely fossiliferous pre-Cincinnatian formations in the Appalachian Valley, central Kentucky, middle Tennessee, Missouri, Arkansas, and Oklahoma, but it should not be interpreted as implying that we have neglected to collect and study these faunas. We have failed only in this, that publication of the results has lagged far behind our information regarding their character and stratigraphic significance.

Having the maximum development of lower and middle Paleozoic marine deposits and also a more detailed conception of the sequence of geologic events recorded in and by them it seems not only natural but also desirable that the American record should be the standard for world-wide comparison. If this were conceded then even very elementary comparisons of classical north European Eopaleozoic sections with American sections of the same era would convince the observer that the composite European sequence is not only inferior in completeness but also that the stratigraphic hiatuses in it are of greater chronologic significance than has been recognized by those most familiar with the fossil contents of the concerned deposits.

EXPLANATORY NOTES ON THE FORMATIONS IN THE SEVERAL COLUMNS

Oklahoma.—This sequence of formations is found on the flanks of the Arbuckle and Wichita Mountains in the south-central part of the State. At the base and resting on pre-Cambrian granite and porphyry are the two Upper Cambrian formations. Over these comes the great series of dolomitic and pure limestones to which Taff applied the term Arbuckle limestone, but which is subdivided into a number of formations in a work nearing completion. The lower part is divided into six oscillating Ozarkian formations, two of which are confined to the Arbuckle area, two to the Wichita area, and two are datum planes common to both. The greater upper part of the Arbuckle is of Canadian age and divided into three formations, the limestones of the Lower and Middle Canadian being provisionally united in one and the lithologically more varied beds of Upper Canadian age into two.

The succeeding Simpson of Taff's classification comprises seven variously distributed and interfingering formations. Of these only the topmost (Bromide) has been previously named. The others are newly named as in the table. Each begins with a sandstone of

from a few feet to more than 100 feet in thickness and is distinguished from the others by a complete change in the character and in most cases also in the derivation of its fauna. The first (Joins) and second (Oil Creek) derived their faunas from the west, whereas the third (McLish) contains species of the Appalachian Lenoir fauna, which therefore are regarded as indicating an invasion from the east at this time. The fourth (Falls) contains species found elsewhere in America only in Nevada and western Texas, which is interpreted as showing that the sources of the invasion was again in the Pacific. The fauna of the fifth formation (Tulip Creek) compares closely only with Stones River faunas of Tennessee, and is therefore held to be an Oklahoma recurrence of that southern fauna during Blount time that did not reach central Tennessee. The fauna of the sixth (Criner) formation again differs radically from that of the next underlying formation. Genetically comparable fossils occur only to the east in Blount and Chambersburg formations. Finally, the faunules of the succeeding Bromide formation are essentially the same as those found in the Black River and early Trenton formations in Iowa and Minnesota, whose northern origin has long been recognized.

The position of the succeeding Viola limestone in the time scale can not as yet be fixed with precision. We know, however, that it follows the Trenton, so that it must fall somewhere in the Cincinnatian or into the hiatus that everywhere separates that series from the Richmond. Its graptolites compare rather well with the Upper Hartfell of Britain, and its trilobites, among which species of *Cryptolithus* predominate, agree better with British Caradoc forms than with any other trilobite fauna known. The Tyner and Sylvan are early Silurian and clearly correspond to parts of the Maquoketa of Iowa. Above these come thin limestones of Upper Medinan and Clinton ages that are better developed in eastern Missouri and northern Arkansas.

Mississippi Valley.—At the base of this column the Ozarkian and Canadian depositional record between the top of the Upper Cambrian and the base of the Buffalo River series in Missouri is broadly indicated on the left side and the inferior record of the same systems in Wisconsin on the right side. Throughout the valley north of Tennessee limestone of Black River age rests on the Buffalo River series. Evidently, about 10,000 feet of deposits—more than half of this thickness consisting of limestone—that occur in east Tennessee and other parts of the Appalachian Valley are wanting in States bordering the Mississippi. Generalized, but in most cases very detailed correlations of the formations of the Mohawkian series in this column with those in Oklahoma, Kentucky, Tennessee, or

New York are too well established to require further comment here. But the case of the succeeding Galena dolomite is quite different. The more I study this formation the less I am satisfied with the reputed Trenton age of its typical parts. Provisionally, and mainly to emphasize my doubts regarding its precise age, I have moved it up in the scale opposite the Cincinnatian. At present it seems that the dolomite in the vicinity of Dubuque, Iowa, is certainly a younger formation than the Kimmswick limestone of Missouri, with which it has been correlated by other geologists; and some of the beds that have been assigned to the Galena in Wisconsin are older than Trenton, whereas others are younger than the Maysville of Ohio. A special paper needs to be written about the Galena.

Ohio Valley.—No deposits of the Buffalo River series occur in Tennessee, but in Kentucky a calcareous phase of one of its sandstones is found in deep wells as far south, at least, as Lexington. Over it are at least three of the limestone formations that make up the Stones River group in central Tennessee. This group attains greater thickness in the western third of the Appalachian Valley, but pinches out completely and rapidly to the west of the Cincinnati anticline. The absence of the southern Appalachian Mosheim limestone in both Kentucky and central Tennessee is a notable feature of this column. Formerly the Mosheim was believed to be included in, or to underlie, the horizon of the Murfreesboro limestone. However, in August of 1928 Doctor Butts and I studied a completely exposed section in the eastern part of Lee County, Va., in which both formations occur in typical development and in which the Mosheim *overlies* the Murfreesboro. In the next Ordovician belt to the southeast the Murfreesboro is absent and the Mosheim as usual in contact with the eroded top of the Canadian system.

In Kentucky and Middle Tennessee the Lowville limestone of the Black River group is in contact with the top of the Stones River, the great Blount group and also the succeeding Little Oak limestone of east Tennessee and Alabama being absent. The Black River also lacks some hundreds of feet of limestone beds that are present in the section of Mulberry Valley north of Sneedville, Tenn. The Trenton, however, is more fully represented, though its beds and fossils are very different from the beds and fossils of similar age in New York and Pennsylvania. The Prosser of Minnesota, being closely akin to the New York Trenton, differs in like manner from the Trenton of Kentucky and Tennessee. Evidently the New York-Minnesota Trenton faunas invaded the continent from a different source than that which supplied the life of Trenton formations in Kentucky and Tennessee. As these northern and southern facies of the Trenton have not yet been found interfingering or mingling

with each other we can not say what, if any, differences in age the observed differences in their respective faunal contents may indicate.

In essentials the Cincinnatian series is much the same on the Cincinnati axis as in New York. However, both regions exhibit faunal and lithologic details that distinguish the sequence in one from that of the other. Most of these differences have been discussed by Ruedemann,[36] but to appreciate their full significance many as yet unpublished facts that have been disclosed by study of this part of the column in Pennsylvania and Virginia must be taken into consideration. Obviously the subject is too intricate to warrant anything more than its mere mention on this occasion. The case is similar with respect to the Medinan formations concerning which so much wholly unpublished, or only partly published, information is in hand that adequate discussion of its problems constitutes the material of another of my uncompleted papers.

Southern and middle Appalachian region.—It would require at least 10 columns to present in correct and readily understandable manner the variations in sequence of the Ozarkian, Canadian, Ordovician, and later formations that are known to occur in the Appalachian Valley region from central Pennsylvania to central Alabama. The sections would be in sets of twos and threes taken at intervals across the strike of the valley troughs and two, or better three, sets taken at points along the strike. But, however, interesting and illuminating such a series of columns would be, my present purpose is particularly concerned only with the oscillations in the valley troughs that are indicated by the distribution of the Chazyan deposits and faunas. Accordingly this column may be characterized as a rather unsatisfactory composite presentation of the frequently varying sequence of formations in the southern and middle stretches of the Appalachian geosyncline.

Absence of the Buffalo River series emphasizes the chronologic significance of the break between the Ordovician and Canadian systems. As a rule the value of this hiatus in the valley south of Staunton, Va., is further increased by absence of the Murfreesboro which, as above mentioned, has been observed to wedge in from the west in the eastern part of Lee County, Va. Elsewhere in the valley Ordovician sedimentation usually begins with greatly varying thicknesses of Mosheim limestone, but there are many places in Virginia, Tennessee, and Alabama at which not only the Mosheim but also most or all of the Lenoir and the Holton are missing, so that the Athens shale is in contact with the Canadian.

The facts just mentioned and the many similar variations that occur at the contact between the Canadian and Ordovician wherever

[36] Ruedemann, Rudolf, The Utica and Lorraine formations of New York, New York State Mus. Bull. No. 258, 1925.

rocks of these ages were deposited in North America constitute the physical part of the evidence on which I base my claim that this is one of the most important breaks in the Paleozoic column. And the organic part of the evidence is no less impressive. The stratigraphic significance of the gap between the two systems is narrowed to its observed minimum in Lawrence County, Ark., where it is reduced (1) by the insertion of two formations at the top of the Canadian that are not present elsewhere in the Ozark region and (2) by the downward expansion of the Buffalo River series which attains its maximum development in Newton County about 100 miles west of Lawrence County. To the north and west of Newton County the chronologic significance of the gap then increases rapidly to places at which the Powell or even the Cotter—respectively, the third and fourth formations beneath the top of the Upper Canadian—is directly succeeded by deposits of Mississippian age. Surely, conclusions based on such data deserve respect and more general acceptance.

Proceeding with the explanatory notes on the middle and southern Appalachian column, the conventions employed indicate that the Murfreesboro, Pierce, and Lebanon formations lap out eastwardly and the Mosheim pinches out in the opposite direction. The Lenoir, however, seems to extend completely across the valley in southwestern Virginia and is supposed to have attained weak connection with the Ridley in central Tennessee and Kentucky. But no such alternation of Atlantic and southern invasions of the Appalachian geosyncline is indicated by the formations of the Blount group, all of which are confined to the eastern half or two-thirds of the valley; and the succeeding Little Oak is found only in one or two of the eastern troughs in Alabama.

In Black River time that excellent datum plane—the Lowville and its red sandy facies, the Moccasin or "Bays"—began a new series of alternating tiltings in which the southern invasions predominated. The Lowville, itself, extends from the Mississippi River far eastward to East Tennessee and in places there overlaps the Chazyan formations quite to the edge of the overthrusted Lower Cambrian formations. To the north in the middle stretch of the valley the Chambersburg, which invaded from the northeast and follows the Lowville, extends southwardly from Pennsylvania to Lexington, Va., beyond which place it has not been recognized. Usually, and perhaps throughout its extent, the Chambersburg is succeeded by the shaly lower Martinsburg facies of the Trenton. In the belt just within the western side of the valley, in which it is represented by its typical limestone facies, the Trenton is succeeded by either the Reedsburg shale phase of the Cincinnatian or by distinguishable Eden and Maysville formations. In the

southwestern corner of Virginia the Maysville is represented only by its lower formation (the Fairview). At Cumberland Gap and to the south in Sequatchie Valley this is succeeded directly by the Sequatchie formation, which is the southern Appalachian marine equivalent of the Richmond. Following the strike northeastward from Cumberland Gap up the Powell Valley the Sequatchie loses in thickness and probably disappears entirely before reaching Big Stone Gap, so that younger Medinan and finally Clinton beds are in contact with the Fairview.

In the Clinch River Valley belts to the southeast the Richmond is represented by the nonfossiliferous red, probably continental deposit known as the Juniata sandstone. This extends continuously from northeastern Tennessee to central Pennsylvania and thence under cover to western New York, where it is known as the Queenston shale or sandstone. In central Pennsylvania and New York the Juniata and Queenston are underlain by the Oswego ("Gray Medina"), sandstone, also mainly a continental deposit, that is believed to correspond in age with the highly fossiliferous McMillan formation of the Cincinnati section. The Brassfield and Whiteoak represent southern marine invasions that reached the Appalachian Valley only south of Virginia and also only in places that had been occupied previously by the Sequatchie. The Tuscarora and the at least partly equivalent Clinch sandstone rest on the Juniata and like it are unfossiliferous and regarded as continental deposits that in their case correspond in age to the fossiliferous Brassfield and Whiteoak formations which occur in belts to the west of Clinch Mountain. No indication of important movements having occurred during the transition from the Lower to the Upper Medina or, in other words, between the Richmond and Alexandria (or "Albion"), epochs has been observed in the Appalachian Valley region between the Adirondacks and central Alabama.

North Appalachian Valley.—This column pertains mainly to the Ordovician and early Silurian deposits in Newfoundland, Anticosti, and the St. Lawrence and Champlain valleys. The Canadian and Ozarkian formations in this region are not referred to except to state my opinion that zones F, G, and H of the Newfoundland section are of Upper and perhaps Middle Canadian age and that the Ozarkian is represented at Philipsburg, Quebec, by beds of the Upper and the Lower series. To this I may add the further opinion that the sections in northern Vermont and at Philipsburg, Quebec, do not include deposits of Middle Ozarkian age; and in the latter section only one of the Champlain Valley Beekmantown formations, namely, the Cassin limestone, has been recognized. Regarding the Chazyan

formations further comment is regarded as unnecessary because the statement and braces on the chart give a sufficiently clear illustration of my belief that the formations and zones of this age in the northeastern St. Lawrence extension of the Appalachian Valley region fall between rather than opposite the formations in its southern part (see pp. 57 and 76). The Lowville and the in part sandy shales (Snake Hill, Canajoharie, and Schenectady), that are correlated with the lower half of the Martinsburg occur in the Champlain and lower Mohawk valleys. The Richmond, Alexandria, and Clinton formations at the top of the column occur on the Island of Anticosti.

In 1923 [37] I referred the Gun River formation of the Anticosti section to the Lower Clinton. This was done on unimpeachable fossil evidence found on slabs that had been sent by Doctor Twenhofel to Doctor Bassler for report on the Bryozoa and Ostracoda and which were marked as collected by the former in the Gun River formation. Twenholfel's final report [38] on the "Geology of Anticosti Island" now being at hand it appears that these supposed Gun River fossils were either incorrectly labeled or the beds from which they were collected were subsequently assigned to the lower part of the Jupiter River formation. Despite the elimination of these unquestionably Lower Clinton fossils review of the revised lists of Gun River fossils in Twenhofel's last report still leaves considerable and perhaps sufficient ground for my 1923 view. At present, therefore, I will modify it only so far as to say that the Gun River is mainly and perhaps entirely of Clinton age. The underlying Becsie I regard as either contemporary with the Brassfield or slightly older but not as old as the Edgewood of Missouri and southern Illinois. The Ellis Bay falls somewhere between two or opposite one of the three or four Upper Medinan formations that underlie the Brassfield in the Mississippi Valley. Partly to indicate the uncertainty of these correlations—but mainly because alternate arrangement of the units accords with my view that, as a rule, formations in the eastern part of the St. Lawrence trough are not precisely correlatable with those of nearest dates in interior basins—the Gun River is placed midway between the Clinton and the Brassfield and the Becsie just beneath the space alotted to the Brassfield.

Britain.—This column begins with the Tremadoc, which I believe belongs rather low in the Canadian and may be correlated in general with the *Dictyonema flabelliformis* zone of the Bretonian of Matthew and the Schaghticoke shale of eastern New York. The Shineton

[37] Ulrich, E. O., and Bassler, R. S., American Silurian formations: Maryland Geol. Survey, Silurian vol., pp. 368–372.

[38] Geol. Survey Canada, Mem. 154, 1928 (title page reads 1927).

seems to be nearly of the same age, but the Arenig, which succeeds it, is more confidently assigned to the Upper Canadian. The Durness on the northwest coast of Scotland belongs to another province and is closely related to American formations of the Canadian. Its lower part contains the *Lecanospira* fauna, which characterizes the Middle Canadian in the Appalachian Valley, Missouri, Oklahoma, Texas, and many areas in western North America; and its upper half contains the similarly distributed *Ceratopea* fauna which is equally characteristic of the Upper Canadian. So far as known the Durness comprises only Middle and Upper Canadian. In this respect it agrees with the Canadian as developed in Missouri and northern Arkansas and in Alabama, Tennessee, and most of the valley in Virginia. The lower Canadian series is differently and less widely distributed. In the Mohawk Valley in New York and probably also in New Jersey no higher beds of the system are present. However, in the vicinity of Ticonderoga, N. Y., again in central and southern Pennsylvania, and thence southward through Maryland to some unknown point in northern Virginia, and finally in the Arbuckle and Wichita uplifts in Oklahoma the Middle and Upper Canadian limestones are underlain by varying thicknesses of the lower series. The observed maximum of 3,000 feet (Jonesboro limestone), is attained at Limestone, Tenn. The section at this place is further unusual because the excellently exposed Jonesboro limestone is directly succeeded by a 50-foot development of Lenoir limestone and this by Athens Shale.

A small variety of *Didymograptus bifidus* is said to occur in the basal part of the Llandeilo. In America we have two small varieties of this graptolite, and both occur near the boundary between the Canadian and the Ordovician. One occurs in Lawrence County, Arkansas, near the top of the Black Rock limestone, which is the youngest of the Canadian formations in the Mississippi Valley. The other occurs near the base of the Joins limestone with which the Ordovician (Ulrich), begins in Oklahoma. Which of the two is most like the Llandeilo variety remains to be determined.

SUPPLEMENTARY NOTES ON THE GIRVAN DISTRICT SECTION

In deference to my belief that the Ordovician formations of the Girvan District named in the middle part of this column are with two exceptions not strictly correlatable with Appalachian formations, I have placed the names of most of them in midway positions with respect to those of the latter. The following notes on the Girvan section, which became possible only since my visit to Girvan the past summer with Prof. O. T. Jones and other British and American members of the Princeton University Summer School of Geology in

Britain, seem more appropriate here than in preceding parts of the paper.

The Stinchar limestone of the type locality rests on the Kirkland conglomerate which presumably represents the clastic initial deposit of the Stinchar stage of submergence. The conglomerate rests—doubtless unconformably—on Radiolarian cherts and black shales said to contain Arenig (Upper Canadian) graptolites.

Lithologically and to notable extent also faunally the upper part of the typical Stinchar is strikingly like the upper part of the Lenoir limestone in Tennessee and Virginia, a fact observed and commented on by Professor Jones when we studied the natural outcrop of the formation and its unweathered appearance in the quarry. The lower part of the Stinchar also resembles lower beds of the Lenoir, so that as a whole the formation strongly suggests approximate equivalence to the mentioned American formation.

The limestone exposed in the quarry at Craighead, about 3 miles east of Girvan and which supplied many of the distinctive fossils of the district, is generally classed as Stinchar limestone. But this correlation is almost certainly in error. The supposed age equivalence of the Craighead and Stinchar limestones evidently arose from the fact that Lapworth in describing the section at Craighead regarded the limestone in the quarry as being succeeded normally by a shale formation from which he had collected Glenkiln graptolites. In other words, Lapworth decided that the sequence at Craighead is the same as on the Stinchar where shale of Glenkiln age lies in normal sequence on the typical Stinchar limestone.

I doubt that any of our 1929 party left the Craighead quarry unconvinced that the well displayed superposition of the shale on the limestone in the quarry is due to overthrust faulting and not original deposition—namely, that the Glenkiln shale has been thrust over a much younger, probably Medinan, limestone formation. All agreed, too, that the Craighead limestone is very different in lithic and faunal characters from the previously investigated typical Stinchar. So far as I have been able to learn not a single species of fossils is common to the limestones of the Craighead and the Stinchar. Besides, the published fauna of the typical Stinchar makes but a short list, whereas a total of at least 85 species has been collected from the Craighead quarry limestone.

The relations of the Craighead limestone fauna to that of the Balclatchie group is much closer. In fact, of the 85 Craighead fossils Reed's lists of Girvan fossils described in his monographs indicate that 37 of the trilobites and brachiopods are present also in the Balclatchie beds. It should be noted, however, that with very few exceptions Reed expresses some doubt regarding the actual specific identity

of the species listed as common to the Balclatchie and the Craighead limestone. The latter, of course, is referred by him to the Stinchar, and its fossils are listed under that heading. Comparison of Reed's lists therefore indicates a much greater similarity in the fossil contents of the Stinchar and Balclatchie formations than is warranted by the facts. Indeed, I am confident that revision and correction of the lists will show that not a single species of the true Stinchar passes upward into the Balclatchie.

Evidently the Craighead fauna comprises a large proportion—approximately 40 per cent—of derivatives of Balclatchie species. Many of these may be very close relatives that as preserved are not readily distinguishable from their ancestors. However, experience shows that with good and abundant material and closer attention to details of structure these difficulties of discrimination will become much less and in most instances quite ordinary. Moreover, this similarity of faunas is precisely what should be expected and what we are experiencing over and over again in comparing faunas that invaded from the same sea at more or less widely different times.

The Balclatchie, despite the mentioned faunal similarity to the Craighead, is unquestionably Ordovician in age. The only question is how far beneath the top of the American development of the system does it belong? In my opinion the Balclatchie, together with the Benan conglomerate which I regard as the initial deposit of its time, is not older than the Tellico of east Tennessee and both most probably are entirely post-Blount age. The Ardwell Group then may be placed near the middle of the Black River Group. I have recently procured what seems good faunal and physical evidence for this view in northern Virginia, but more field work and further study of the fossil collections is desired before I shall feel prepared to discuss the problem.

In the case of the Whitehouse group positive faunal evidence tending to show its stratigraphic relations to Appalachian formations is as yet scant and far from conclusive. However, taking into account all of the faunal similarities now suposed to have any bearing on the question together with probabilities suggested by the lithic character of underlying and overlying formations in Girvan, we may be safe in placing the Whitehouse within the limits of the Trenton group or perhaps at the contact of the Trenton and Eden groups. After this disposal of the Whitehouse and the more confident reference of the Drummuck to the Medinan the intervening Barren flagstones seem to fall very naturally into the space occupied in America by the Upper Cincinnatian (Maysville group). The Girvan beds supposed to be of this age agree particularly well with the upper part of the Pulaski group and the Oswego sandstone as developed in parts of New York and Pennsylvania.

THE ASHGILLIAN OF NORTHWESTERN ENGLAND

Marr's term Ashgillian does not appear on the chart, but since I enjoyed an opportunity the past summer to study the typical and best known exposures of the series in northwestern England under the able guidance of T. C. Nicholas and W. B. R. King, both of Cambridge University, some expression of my opinion concerning the age of the beds covered by the term seems desirable. As defined by Marr [39] and as the beds and fossils appeared to me in the field, the Ashgillian should fall within the Medinan epoch. Whether any part of the series is of Richmond age I am not prepared to say, but the upper part at least I am strongly inclined to refer to the Alexandrian.

Let me say further that at no place visited by us in 1929 did we see any convincing contact between beds admitted by our guides to be very low Silurian and beds of Ashgillian age that my British friends classify as "Upper Bala" or "Caradocian" and therefore as "late" Ordovician. The supposed "contacts" and sometimes "passage" beds that were pointed out as marking the transition from the Ordovician to the Silurian in no case presented the diastrophic criteria and qualities that in America we insist on being definitely located in the outcrop and indubitably shown to be present at the Ordovician-Silurian contact. However, much more convincing and diastrophically well marked contacts occur in the Lakes District and elsewhere in Britain between lower beds, but as their fossils consist mainly of Ordovician generic types and perhaps particularly because they lack monograptids they are referred by the British geologists to the Ordovician system.

In my opinion the naturally defined base of the Silurian in the English Lakes District lies at the base of the Coniston limestone series. This series begins with the "Stile End beds," 0 to 50 feet thick and consisting of sandstones, grits, and as much as 10 feet of coarse conglomerate at the base. The Stile End beds are succeeded by the Applethwaite beds—calcareous shales, banded and nodular limestones—about 100 feet thick, with a basal zone full of pebbles derived from the underlying Borrowdale volcanic series. Here and there the Applethwaite limestone is highly fossiliferous, the fauna consisting mainly of corals. But these corals—among them several species of *Heliolites*—are of kinds that viewed in the light of American occurrences could indicate nothing older than topmost Medina or Clinton. The Applethwaite is succeeded by Marr's Ashgill group, 70 feet thick, with the Phillipsinella beds at the base and the Phacops mucronatus beds—now admitted by Troedsson to be Silurian—in

[39] Marr, J. E., The Lower Paleozoic rocks of the Cautley District: Geol. Soc. London Quart. Journ., vol. 69, p. 5, 1913.

the middle third. The Ashgillian is succeeded by the Skelgill beds. These comprise a number of thin zones with species of *Monograptus* and at the base a thin limestone with *Atrypa flexuosa* and directly over this a black mudstone with *Dimorphograptus*.

Just why the first appearance of monograptids, unheralded as it usually is by a well-marked physical break, should determine the beginning of the Silurian system and the close of the Ordovician is not clear to me. It is merely an event in the course of Silurian history and one that can hardly be expected to have been manifested at precisely the same time everywhere. It is no more important than the first appearance of *Fenestella* in the Richmond or of *Hemitrypa* in the Brassfield or of *Coelospira* and *Spirifer* in the Clinton or of the subsequent first appearances of many other generic types that became abundant and lasted for long periods thereafter.

In America we also find it troublesome to detect a satisfactory physical or faunal boundary between the Richmond and the Alexandrian, and considerable difference of opinion as to the precise location of the Medinan-Clinton boundary is notable in American literature. However, as regards the systemic boundary, the best informed American stratigraphers—at least those who have learned their stratigraphy from field observations in many areas rather than from laboratory studies and comparisons of collections of fossils—are well satisfied to follow the footsteps of the geologists of the first geological survey of New York, who in the forties of the last century drew the boundary between their Ontario and Champlain divisions of the New York system at the generally clearly marked base of the Lower Medinan. The official survey of New York has never, so far as I know, receded from its position on this question except by substituting British terms for New York names.

After four brief but well-filled periods of field studies in Britain, Scandinavia, and Bohemia my conviction that diastrophically well-marked systemic boundaries essentially corresponding in age to those worked out in America may also be determined on the east side of the Atlantic is more firmly fixed than it was on my first visit to Europe in 1922.

Norway and Sweden.—This column requires little explanation. Etage 5 of the Norwegian section and the Leptaena limestone of Sweden are placed into the Silurian for practically the same reasons as those that seemed to demand the removal of the British Keisley and Drummuck formations from the Ordovician to the naturally delimited Silurian system advocated by me. The proper placing of the Norwegian Etage 4 and the Swedish *Trinucleus* (*Tretaspis*) and *Chasmops* zones I find much more difficult. Regarding these Scandinavian zones the *Trinucleus* zone seems at present to belong

high in the Ordovician—perhaps within the broader zone of the American Viola limestone, though the Trinucleidae in the two are quite different. The half dozen species in the latter are of *Cryptolithus*, whereas those in the Swedish formation are of *Tretaspis*. One of the latter is identified with *T. bucklandi*, a Drummuck species in Scotland, which according to preceding argument (pp. 61–69) is early Silurian rather than late Ordovician. But the Viola also is not firmly fixed in the position given it on the chart. We know only that it is younger than Trenton and in unconformable contact with the Fernvale above. It may therefore correspond to the whole or to some part of the Cincinnatian, or, if it does not belong between the Eden and the Maysville, its place may be in the hiatus between the Maysville and the base of the Richmond. The fauna gives no conclusive indication whatever, and what evidence it does present seems to favor the last interpretation rather than the others. If the *Trinucleus* zone proves older than the Viola the position of the underlying *Chasmops* will also be lowered in the scale.

Etage 3^{c} (*Orthoceras* limestone) probably is older than given on the chart. A positive statement is not yet warranted, but judging from its fossils I am inclined to believe that eventually Etage 3^{c} and the Kunda of the Baltic Province will be found to correspond to our Buffalo River series.

Baltic region.—Above the Wesenberg no material change has been made from the correlations indicated in the table published in my 1926 paper on the Ordovician-Silurian boundary. The Borkholm is again correlated with the Leptaena limestone of Sweden and the Keisley of England, and all three are placed in the general horizon of the Upper Medinan. The Lyckholm, also, is referred as before to the Richmond. More doubt is entertained regarding the position of the Wesenberg and also as to the stratigraphic relations of the Kegel and the four members of the Wierland group of Raymond to Ordovician formations of America. A somewhat lower position is suggested for the latter than in the preceding paper; but I am not certain that the present arrangement is nearer the truth than the other. On the other hand, I can not free my mind of the suspicion that most if not all of these east Baltic formations were not deposited at strictly the same times as those in either of the Scandinavian countries or those in England, Scotland, and Ireland or those in North American areas, with which they have hitherto been more or less confidently correlated by others as well as by me.

EXPLANATION OF PLATES

PLATE 1

Page

FIG. 1. *Telephus reedi,* new species 19

Copy of Reed's figure of the cranidium of this Girvan species that he had referred, probably erroneously, to *T. fractus* Barrande; × 3.

Whitehouse group, Girvan District, Scotland.

2. *Telephus* species undetermined:

Copy of Hadding's figure of a small specifically undetermined cranidium of this genus, × 5. Compare *T. spiniferus* and *T. wegelini.*

Lower Dicellograptus shale near Röstånga, Sweden.

3–7. *Telephus fractus* Barrande 10

Copies of Barrande's illustrations of this species; all natural size except fig. 5, which is × 2.

Etage, D_4, Lodewitz and Koenigshof, Bohemia.

8–10. *Telephus jamtlandicus,* new species 13

8. Imperfect cranidium, × 1 and × 4, that is provisionally distinguished under this name from the other specimens figured and referred, apparently in error by Hadding to *T. bicuspis* Angelin. Copied from Hadding.

9, 10. Side and anterior views of same, × 4.

Lower part of Ogygiocaris shale, Jämtland, Sweden.

11–18. *Telephus haddingi,* new species 12

11,12. Different views of free cheeks with eyes, × 9.

13, 14. Dorsal views of two cranidia, × 2.

15, 16. Anterior and sideviews of a larger cranidium, × 2.

17. Imperfect pygidium, with transverse and longitudinal profiles, × 6.

18. Incomplete thoracic segment, × 5.

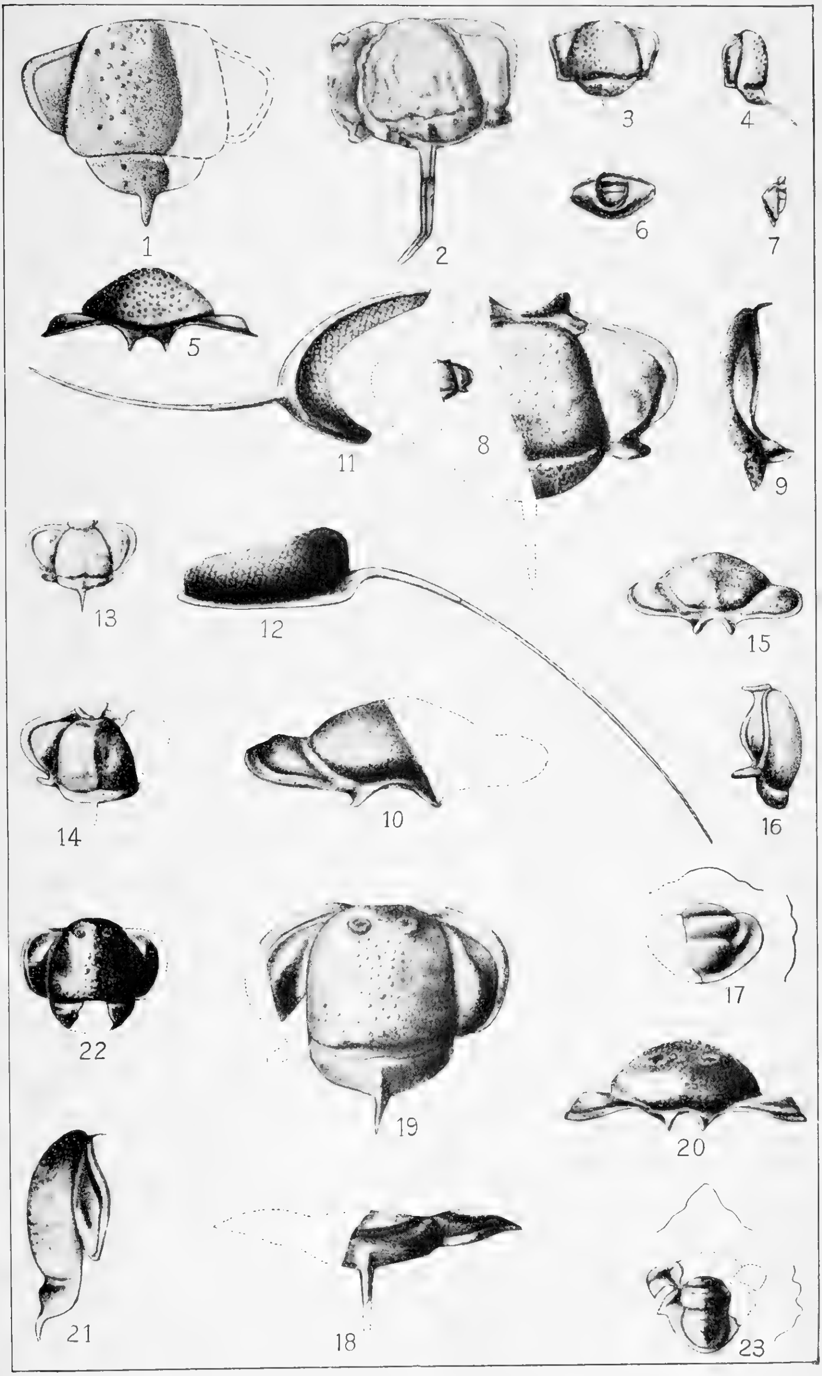
Figures copied from Hadding's paper in which these specimens are referred to *T. bicuspis.* For copies of Angelin's figures of the Norwegian types of his *T. bicuspis* see pl. 2, figs. 20, 21.

Lower part of Ogygiocaris shale, Jämtland, Sweden.

19–23. *Telephus granulatus* Angelin 11

Copies of Hadding's figures of Swedish specimens of cranidia and a pygidium referred by him to this species. The two cranidia seem to differ slightly and neither is quite like Angelin's figure of the Norwegian type of the species. For copy of the latter see pl. 2, fig. 13.

Upper part of Ogygiocaris shale, Jämtland, Sweden.



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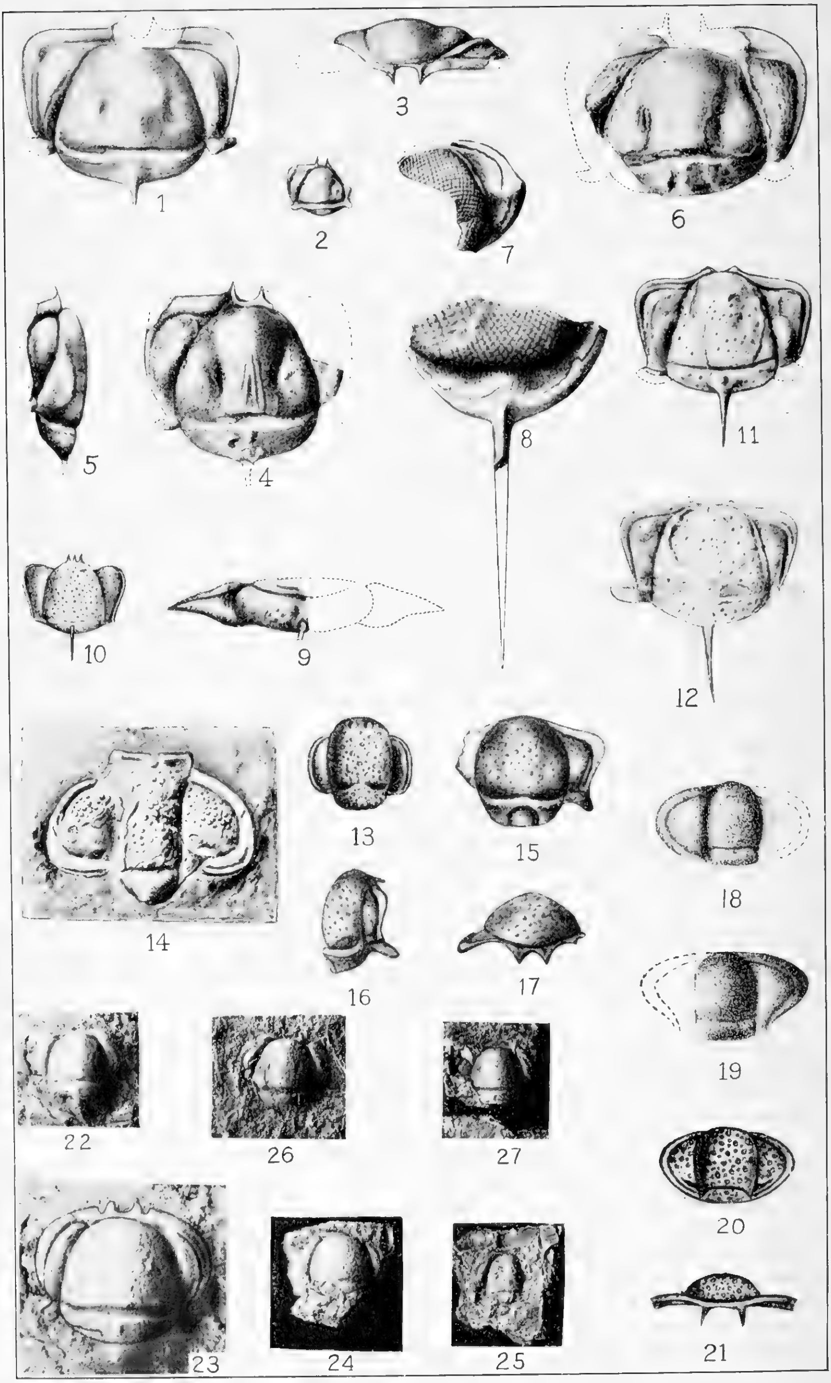

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Plate 2

		Page
Figs. 1–9.	*Telephus mobergi* Hadding	14

1. A small cranidium, × 4.
2. Dorsal view of another cranidium, × 1.
3–5. Anterior, dorsal and side views of same, × 3.
6. Dorsal view of a large cranidium, × 3.
7, 8. Free cheeks with broken eyes, × 3 and × 5.
9. Half of a thoracic segment, × 3.

Copies of original figures in Hadding's paper. Basal beds of the Ogygiocaris shale, Jämtland, Sweden.

10–12. *Telephus wegelini* Angelin 13

10. Copy of Angelin's original figure of the cranidium of this species. The middle spine shown in front doubtless is a misapprehension.
11, 12. Copies of Hadding's figures of two cranidia, × 3.

Black Trinucleus shale, Dalarne, Sweden.

13. *Telephus granulatus* Angelin 11

Copy of Angelin's figure of the type of this species.

14. *Telephus ? salteri* Reed 20

Copy of Reed's dorsal view of the type of this strange species. As given by Reed, the greatest width of this cranidium is 5.4 mm.

Balclatchie group, Balclatchie, Girvan District, Scotland.

15–17. *Telephus linnarssoni*, new species 15

Dorsal, side and front views, × 3, of the holotype of this species; after Warburg.

Leptaena limestone, Boda, Dalarne, Sweden.

18, 19. *Telephus hibernicus* Reed 17

Copies of figures of two cranidia of this species, × 4, after Reed. The lower figure suggests shortening by compression.

Tourmakeady Beds, County Mayo, Ireland.

20, 21. *Telephus bicuspis* Angelin 12

Copies of Angelin's original figures of this species. (See also pl. 1, figs. 11–18).

22–27. *Telephus americanus* Billings 21

22, 23. Dorsal views, × 2 and × 4, of the selected holotype of this species. The figures given by Hadding were made from a plaster cast of this specimen. It seems also to be the one from which Billings' illustration was prepared.

24, 25. Two other cranidia, the second not completely uncovered, × 2, that agree very closely with the holotype.

26. A fourth cranidium, × 2, that differs enough in the shape of the glabella to suggest a distinguishable species or variety.

27. Probably another cranidium of the preceding variety, × 2. Probably Upper Chazyan (Div. N and P), Newfoundland.

Plate 3

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Figs. 1–10. *Telephus pustulatus*, new species 28

1. Dorsal view of a cranidium, × 3. U.S.N.M. No. 80536*a*.

2, 3. Front and side views of the holotype cranidium, × 3. U.S.N.M. No. 80536.

4. Dorsal view of same, × 4.

5–7. Different views of a free cheek, all × 4, showing its small rim, very large eyes, and the broken base of the genal spine. U.S.N.M., No. 80536*b*.

8. Same view as figure 7 with genal spine restored.

9, 10. Dorsal and end views of pygidium, × 4. U.S.N.M., No. 80536*c*.

Whitesburg limestone, Lexington, Va.

11. *Telephus spiniferus*, new species 29

Dorsal view of the holotype cranidium, × 4. U.S.N.M. No. 80537. Basal 20 feet of the Athens shale, over large Holston limestone quarry, 3 miles southeast of Saltville, Va.

12. *Telephus spiniferus calhounensis*, new variety 30

Dorsal view of the imperfect cranidium, × 4, on which this variety of species is based. Holotype, U.S.N.M. No. 80538. As will be observed, it differs from the holotype of the older typical form of the species in the shape and, apparently also, in the furrowing of the glabella. Athens shale, 75 feet beneath top bluff of Hiwassee River, one and a half miles east of Calhoun, Tenn.

13, 14. *Telephus latus*, new species 26

Dorsal and anterior views of the holotype, × 3. The species resembles *T. pustulatus* but differs in the outline and lesser convexity of the glabella and the general flatness of the fixed cheeks. U.S.N.M. No. 80539.

Thin limestone lenses in the basal 20 feet of the Athens shale, at quarry southeast of Saltville, Va.

15 *Telephus sinuatus*, new species 30

Dorsal view of holotype cranidium, × 4. Glabella somewhat as in *T. spiniferus* but fixed cheeks much narrower. U.S.N.M. No. 80540.

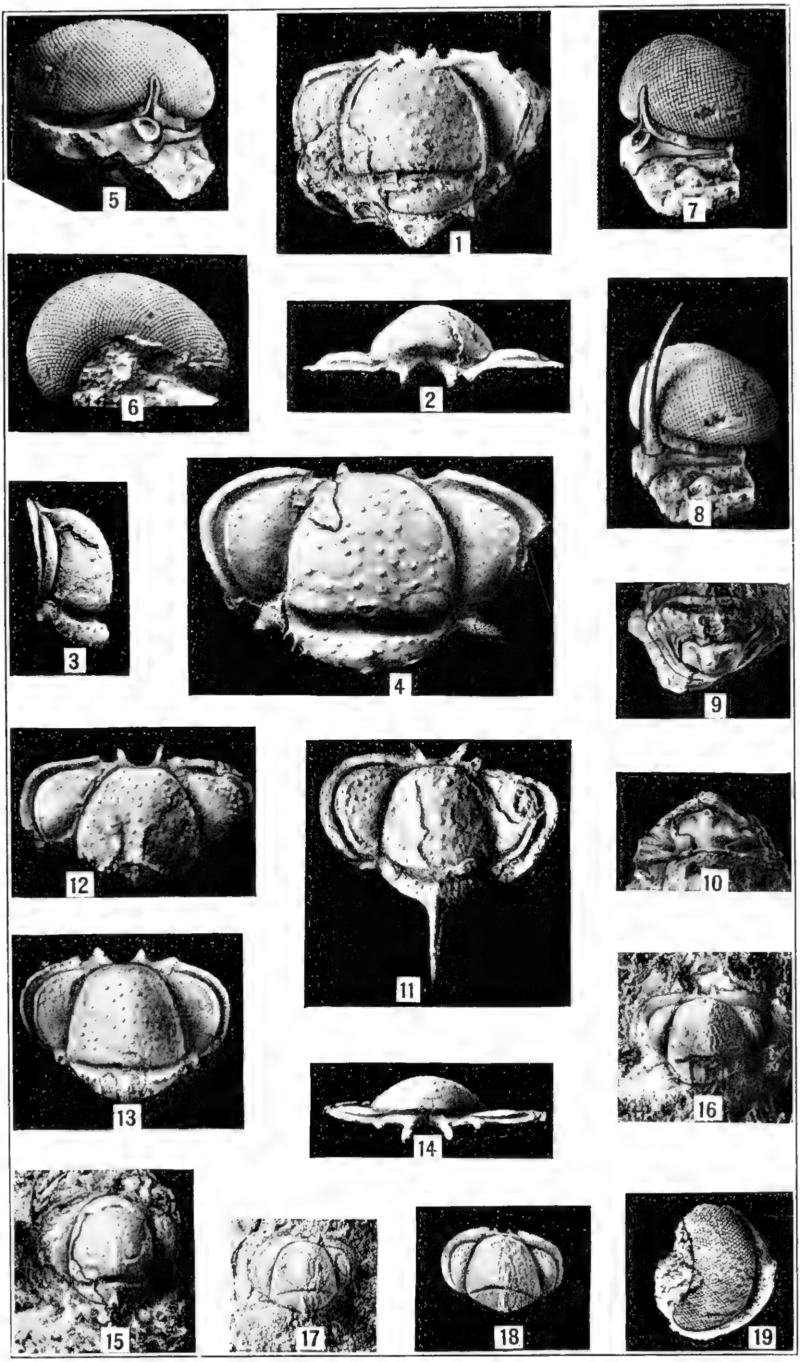
Whitesburg limestone, Lexington, Va.

16–19. *Telephus prattensis*, new species 34

16. Dorsal view of a cranidium from Pratts Ferry, Ala., × 3. Cotype U.S.N.M. No. 80541.

17, 18. Similar views, × 3, of two cranidia from the Whitesburg limestone, 1 mile south of Bulls Gap, Tenn. Cotypes U.S.N.M. No. 80542.

19. Free cheek, × 4, associated with this species and *T. bipunctatus* at Pratts Ferry, Ala. U.S.N.M. No. 80541*a*.



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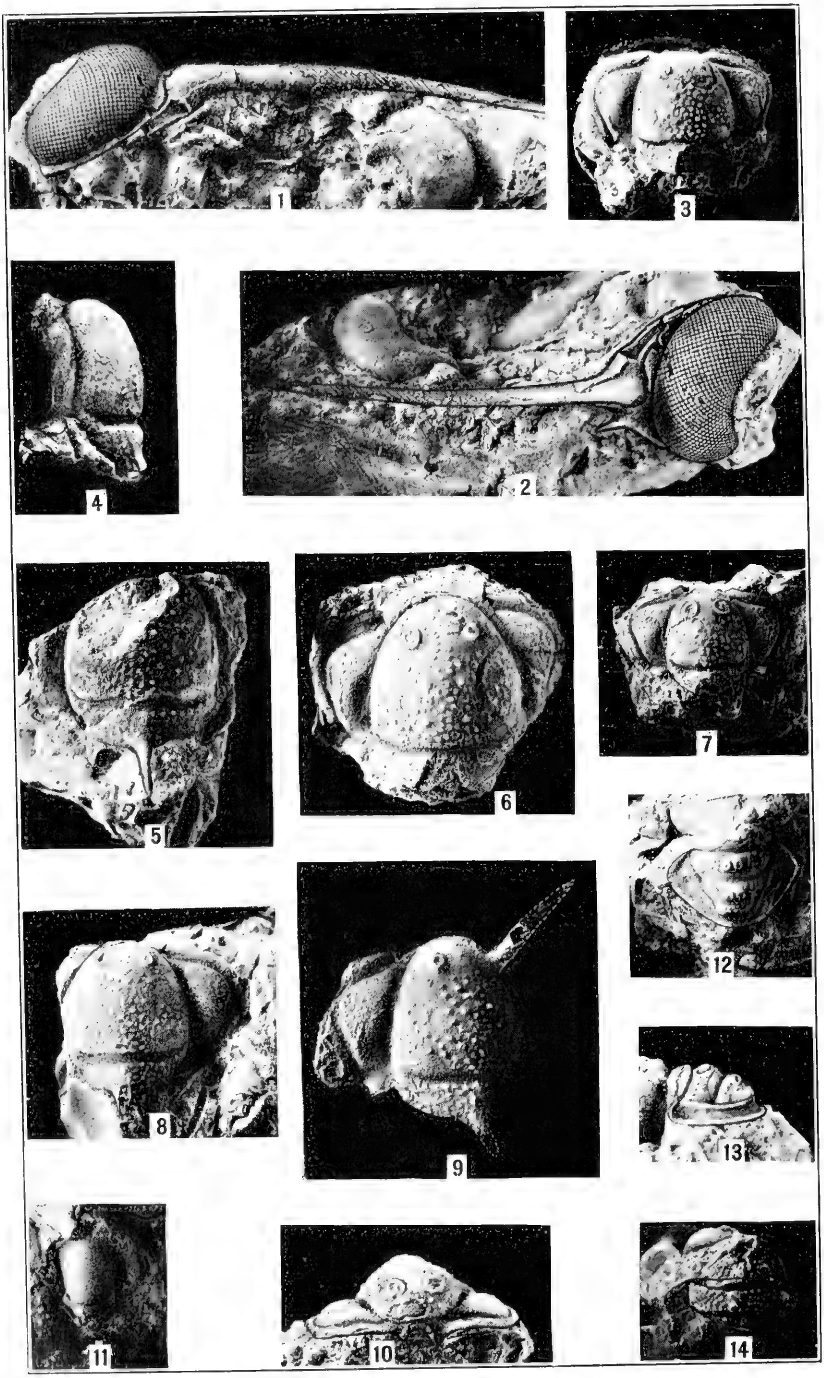

ORDOVICIAN TRILOBITES OF THE FAMILY TELEPHIDAE

FOR EXPLANATION OF PLATE SEE PAGE 93

Plate 4

1, 2. Anterior and dorsal views of a free cheek, × 4. The latter shows the shorter spine behind the longer one which is regarded as the real genal spine. U.S.N.M. No. 80535*a*.

3. Dorsal view of rather small cranidium, × 3. U.S.N.M. No. 80535*b*.

4. Side view of a larger cranidium, × 3. U.S.N.M. No. 80535*c*.

5. Dorsal view of an imperfect cranidium with occipital spine complete, × 3. U.S.N.M. No. 80535*d*.

6. Large cranidium somewhat crushed in right anterior third, × 3. U.S.N.M. No. 80535*e*.

7. Nearly complete but small cranidium, × 3. U.S.N.M. No. 80535*f*.

8. Another cranidium, × 3. U.S.N.M. No. 80535*g*.

9. Still another cranidium that retains about half of one of the glabellar spines, × 3. The specimen was tilted in photographing so as to show the full length of the remaining part of the right spine. U.S.N.M. No. 80535*h*.

10. Anterior view, × 4, of the specimen shown in Figure 7.

11. An associated hypostoma supposed to belong to this species, × 3. U.S.N.M. No. 80535*i*.

12–13. Respectively dorsal and side views of the associated pygidium, × 3. U.S.N.M. No. 80535*j*.

14. One of the thoracic segments, × 3. U.S.N.M. No. 80535*k*. All these specimens are regarded as cotypes of the species, and all were collected from a single ledge of Whitesburg limestone, 5 miles southwest of Bland, Va.

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FIGS. 1–9. *Telephus bipunctatus*, new species 31

1–3. Dorsal, lateral, and anterior views of a nearly perfect cranidium, × 4. U.S.N.M. No. 80543*a*.

4–6. Dorsal views of three other cranidia, × 4, selected to show extremes of observed variations in shapes of parts and in surface sculpture. U.S.N.M. No. 80543*b*.

7, 8. Dorsal and posterior views of a pygidium, × 4. Only the broken bases of the double-headed spines on the axial rings are retained when the specimens are uncovered in breaking the limestone matrix. U.S.N.M. No. 80543*c*.

9. The most complete of the free cheeks, × 4. U.S.N.M. No. 80543*d*.

Whitesburg limestone, Lexington, Va. All these specimens may be ranked as cotypes of the species.

10–15. *Telephus impunctatus*, new species 33

10–13. Dorsal views of four cranidia, × 3, that may be regarded as cotypes of the species. U.S.N.M. No. 80544. The specimen of Figure 12 has been slightly distorted by obliquely transverse pressure.

14. Side view of Figure 13.

15. Pygidium associated with these cranidia, × 4. It is wider and the axis less convex than in *T. bipunctatus* which occurs in the same bed and place. U.S.N.M. No. 80545.

Whitesburg limestone, near Albany, Tenn.

16. *Telephus buttsi*, new species 40

One of three very small cranidia, × 8. All of these have been similarly shortened by compression. Their general aspect suggests *T. bipunctatus* and *T. troedssoni*, but the occipital spine is too long, slender, and round for either of those species. They remind also of *T. mobergi*, but the occipital spine is too long and the fixed cheeks too wide to warrant their reference to that species. U.S.N.M. No. 80546.

Yellow, leached shale, at base of the Athens shale, near Longview, Ala.

17–21. *Telephus troedssoni* Raymond 40

17. Dorsal view of a clay impression taken from the holotype of this species, × 3. The latter is a natural mold of the exterior of an imperfect cranidium, somewhat distorted by compression in slightly oblique direction. Original in Mus. Comp. Zoöl., Cambridge, Mass.

Near base of Athens shale, near Athens, Tenn.

18. An imperfect and distorted cast of the interior of a cranidium supposed to belong to this species. The middle part of the anterior border is well preserved and clearly shows the distinctness of the median anterior pair of spines and the shorter spines to which the ends of the free cheeks are joined. U.S.N.M. No. 80547.

19. An associated cast of the interior of a free cheek with compound eye, × 8. U.S.N.M. No. 80547*a*.

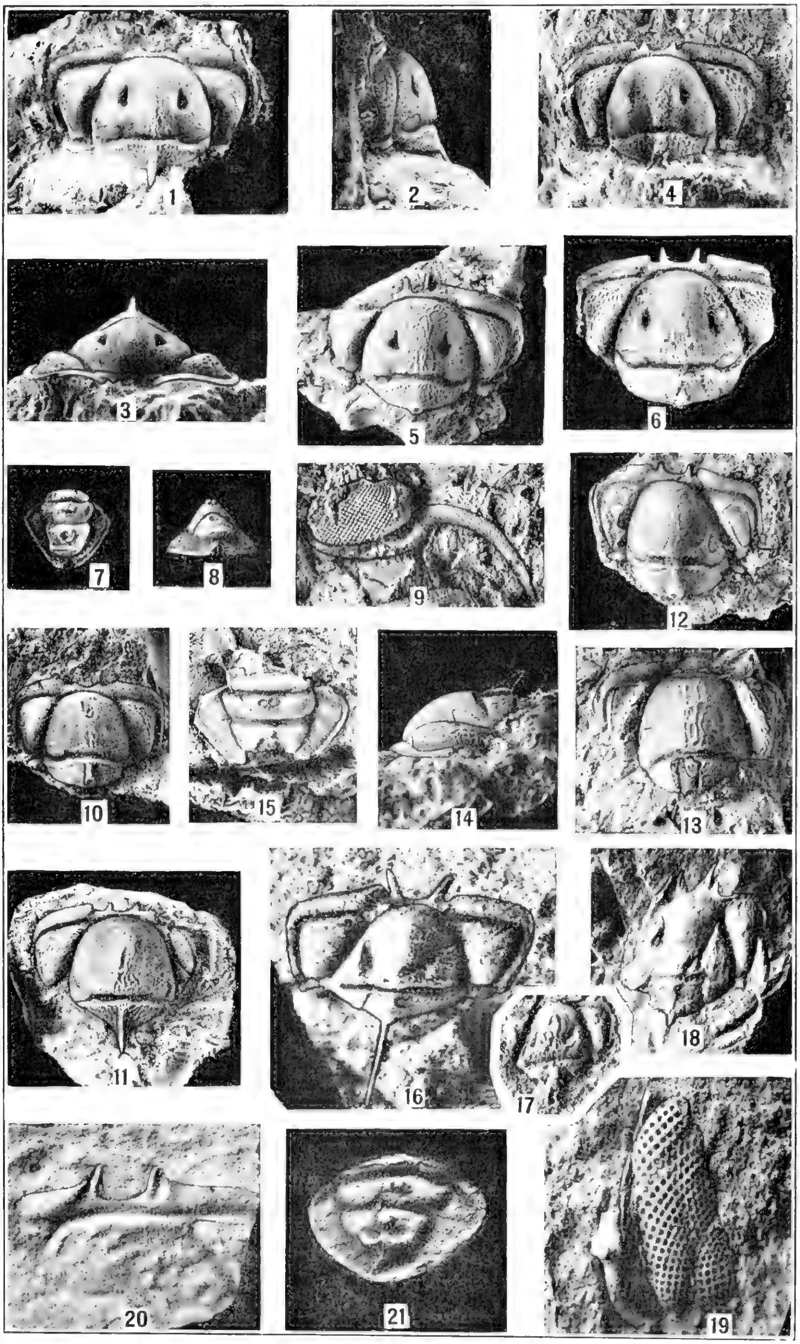

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FIG. 20. Another cast of the interior of a cranidium found with the preceding two specimens, × 8, more doubtfully referred to this species. This has been greatly shortened by pressure and is otherwise imperfect. It is figured mainly because it retains most of the anterior border and shows the separateness of the median pair of spines even in this form, in which their bases are very close to the anterior ends of the facial sutures. U.S.N.M. No. 80547*b*.

21. A pygidium found with the preceding, × 8. Though somewhat shortened by compression, it still shows a greater width of border than is found in other species. In general it reminds most of the pygidium assigned to *T. impunctatus*. U.S.N.M. No. 80547*c*.

All found with *T. buttsi* in the basal part of the Athens shale, 1.5 miles northeast of Longview, Ala.

PLATE 6

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FIGS. 1–7. *Telephus mysticensis*, new species and variety 22

1. Holotype cranidium, × 3. Very similar in general aspect to the cranidium of *T. americanus* but lacks the small surface pustules and the glabella has shallow curved longitudinal depressions that are not present in the types of that species. U.S.N.M. No. 80526.
2. Free cheek with posterior side above, × 4. Paratype U.S.N.M. No. 80527*a*. Possibly the cheek of the var. *simulator*
3, 4. Probably anterior and dorsal views of another slightly different free cheek, × 4. Paratype U.S.N.M. No. 80527*b*. The collections contain four or five of each of these two kinds of cheeks, but to which of the two kinds of cranidia either belongs is, of course, uncertain. The lower side of figure 4 probably is anterior. The periphery of the eye here overhangs the narrow rim.
5 An associated hypostoma, × 4. Paratype U.S.N.M. No. 80527*c*.
6. One of the two associated pygidia, × 4. Paratype U.S.N.M. No. 80527*d*.
7. Cranidium, × 4. Differs in shape and contour of the glabella from the holotype and in size and shape of the fixed cheeks. Probably a distinct species that is provisionally separated as var. *simulator*, new variety. This name is chosen because it greatly resembles the southern *T. prattensis* (see pl. 3). Holotype, U.S.N.M. No. 80528. Boulders of Chazyan limestone, near Mystic, Quebec.

8–9. *Telephus bilunatus*, new species 39

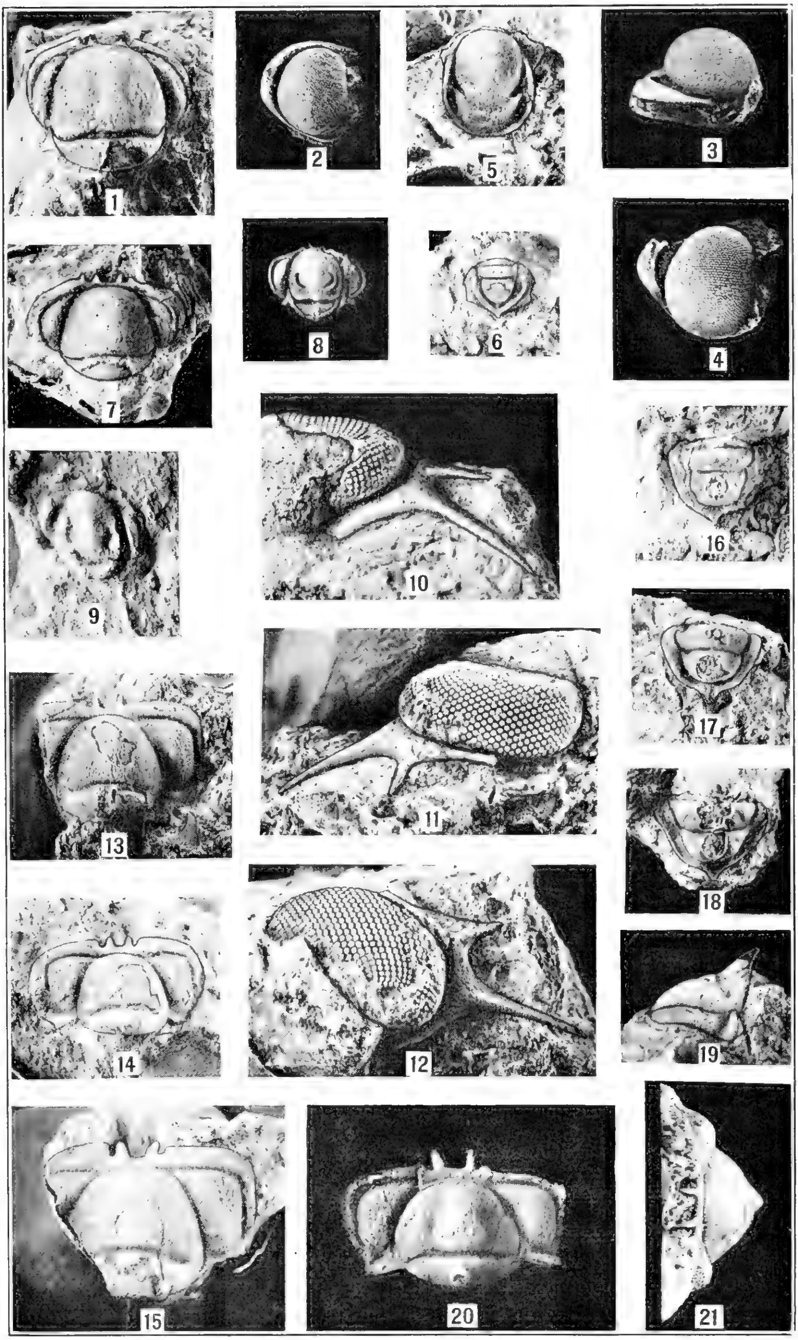
8. Dorsal view of the holotype cranidium, × 4. U.S.N.M. No. 80529. The most characteristic feature of the species is the pair of deep lunate glabellar impressions. Whitesburg limestone, near Albany, Tenn.
9. A cranidium, somewhat larger than the holotype and distorted by lateral compression of the soft shale matrix, × 4. U.S.N.M. No. 80530. From a bed of yellow shale near Longview, Ala., probably of Whitesburg age but provisionally referred to the base of the Athens shale.

10–19. *Telephus tellicoensis*, new species 35

10–12. Three views of a free cheek of a *Telephus* and probably of this species, × 4. U.S.N.M. No. 80531.
13–15. Dorsal views of three cranidia, × 3. Cotypes, U.S.N.M. No. 80532. Anterior and side views of Figure 14 given in pl. 7, figs. 10, 11.
16–18. Three pygidia, × 4, the last showing the shape of the posterior marginal spine. Cotypes, U.S.N.M. No. 80533.
19. Side view of specimen shown in Figure 14, for comparison with *T. hircinus* (see pl. 7, fig. 2). Basal 10 feet of Tellico formation, 1.5 miles southeast of Knoxville, Tenn.

20, 21. *Telephus transversus*, new species 37

Dorsal and anterior views of the holotype cranidium, × 3. Distinguished from *T. tellicoensis* by its greater width and broad hollows in lateral slopes of glabella. U.S.N.M. No. 80534. Associated with preceding.



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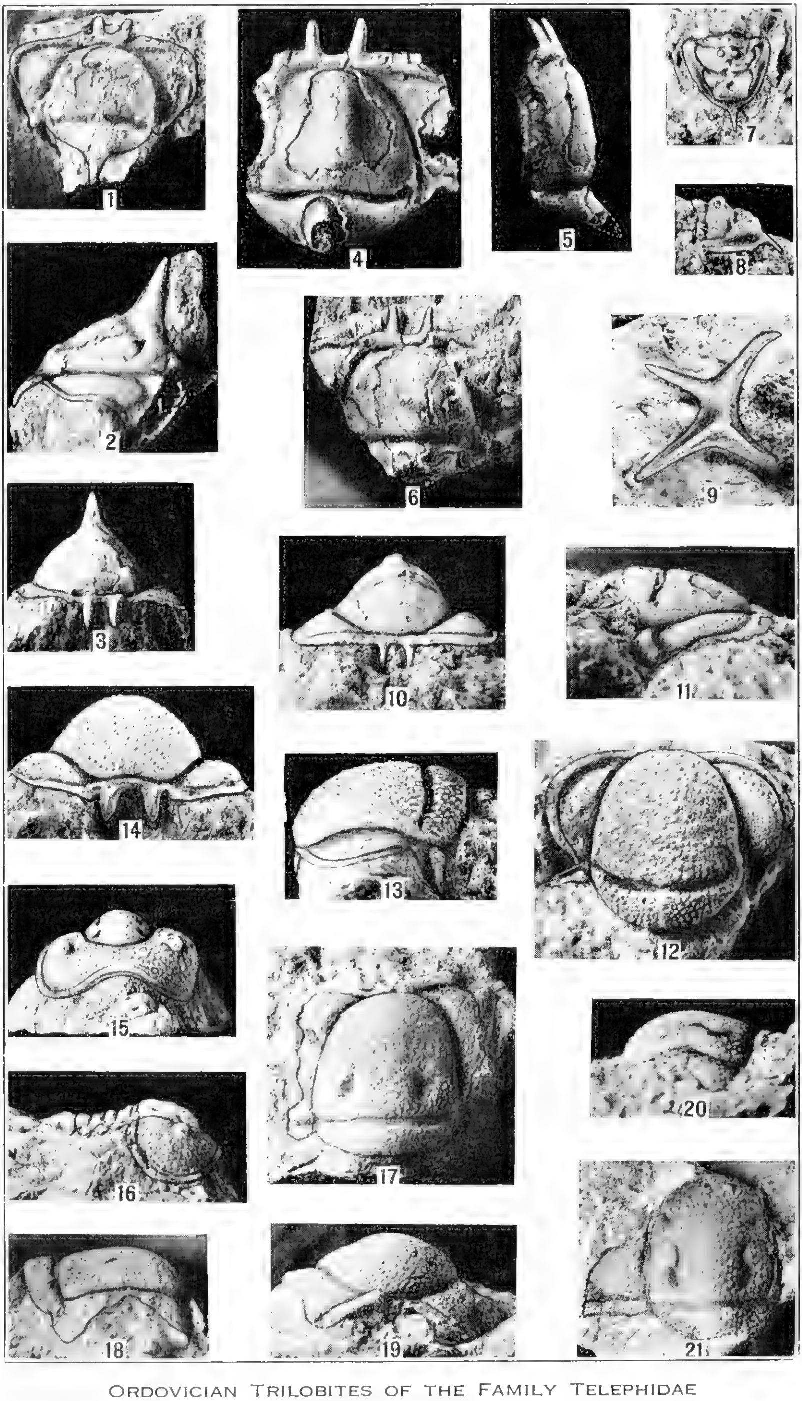

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Plate 7

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Figs. 1–9.	*Telephus hircinus*, new species	38
	1–3. Dorsal, side and anterior views of a small but nearly complete cranidium, × 4. The extraordinary strength and height of the occipital spine and the conspicuous prominence of the anterior denticles are mainly relied on in distinguishing the species from *T. tellicoensis*, its nearest ally. Cotype U.S.N.M. No. 80548*a*.	
	4–5. An incomplete but large and unquestioned cranidium of the species, × 4. Cotype U.S.N.M. No. 80548*b*.	
	6. Another somewhat smaller cranidium, × 4.	
	7, 8. Dorsal and side views of a pygidium supposed to belong here, × 4. Cotype U.S.N.M. No. 80548*c*.	
	9. A free cheek exposing the under side, × 4. Cotype U.S.N.M. No. 80548*d*.	
	Tellico formation east of Knoxville, Tenn.	
10, 11.	*Telephus tellicoensis*, new species	35
	Anterior and side views of cranidium shown in Figure 14 in pl. 6. Cotype U.S.N.M. No. 80532.	
12–14.	*Telephus gelasinosus* Ulrich	26
	Dorsal, side and anterior views of the holotype cranidium of this species, × 4. U.S.N.M. No. 71468.	
15, 16.	*Glaphurus pustulatus*, (Walcott)	42
	Anterior and side views of specimen of which the dorsal view is given in pl. 8, Figure 11. U.S.N.M. No. 80551*h*.	
17–19.	*Glaphurina brevicula*, new species	46
	Dorsal, side, and anterior views, × 2, of the holotype cranidium of this species. U.S.N.M. No. 80549.	
	Holston limestone, 2 miles northwest of Lexington, Va.	
20, 21.	*Glaphurina falcifera*, new species	46
	Side and dorsal views, × 2, of the holotype cranidium of this species. U.S.N.M. No. 80550.	
	Lower Chazyan limestone, 1 mile southeast of Bluff City, Tenn.	

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FIGS. 1–11. *Glaphurus pustulatus* (Walcott) 42

1. Thorax and pygidium of rather small specimen, × 4. U.S.N.M. No. 80551*a*.
2. Two cranidia of medium size specimens, × 4. U.S.N.M. No. 80551*b*. Practically all the "pustules" of the surface are in fact only the bases of slender spines of three sizes. The length of those on the occipital ring is shown on left hand cranidium.
3. One of the largest of the cranidia so far observed, × 4. U.S.N.M. No. 80551*c*. The pair of large anterior spines with two sets of three smaller spines between their bases are restored from another specimen.
4. An incomplete free cheek, ×4, showing the spinose genal spine and imprints of the series of very long minute spines that lines the under side of the outer rim. U.S.N.M. No. 80551*d*.
5. A pair of free cheeks, × 4, separated from the cranidium but still joined by a thin band that lies just within the series of minute marginal spines shown in Fig. 4. This inner band is separated from the outer rim of the cheek by a marginal suture that seems to extend to and beneath the genal spine. Apparently it is a separate plate similar to those found in Mesonacidae, Agnostidae, and certain other trilobites. U.S.N.M. No. 80551*e*.

6–9. Four slightly differing hypostomas, × 4, all found in association with abundant remains of this species and probably belonging to it. U.S.N.M. No. 80551*f*.

? 10. The largest pygidium found with positively identified material of this species, × 3. It is relatively more transverse than the other specimens and differs from them also in details of the axis. As the same block of limestone contained also the two cranidia on which *Glaphurina lamottensis* is founded it is not improbable that it belongs with that species rather than to *Glaphurus pustulatus*. U.S.N.M. No. 80551*g*.

11. Dorsal view of a specimen that consists of the cephalon, with the free cheeks in place, and five of the thoracic segments, × 3. Side and anterior views of same on pl. 7. U.S.N.M. No. 80551*h*.

Fine grained reefy bed at base of Upper Chazy, Isle La Motte, Vt.

12, 13. *Glaphurus latior*, new species 44

Dorsal and anterior views, × 2, of the holotype cranidium. It is to be noted that this cranidium differs from *G. pustulatus* in being larger and relatively wider, the brim narrower and with only two instead of three rows of pustules in front of the glabella. U.S.N.M. No. 80552.

Whiteburg limestone, 6 miles southwest of Bland, Va.

14–16. *Glaphurina lamottensis*, new genus and species 45

Anterior, lateral and dorsal views, × 2, of the holotype of this species. The genus, of which two other species are figured on pl. 7, is distinguished from *Glaphurus* by the total pinching out of the brim between the front of the glabella and the cephalic rim. U.S.N.M. No. 80553.

Reefy basal limestone of the Upper Chazy, Isle La Motte, Vt.

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U S GOVERNMENT PRINTING OFFICE: 1929

MITROSPIRA, A NEW ORDOVICIAN GASTEROPOD GENUS

By Edwin Kirk
Of the United States Geological Survey

For the past 30 years or more fragmentary specimens of a large gasteropod have been collected and sent in by Geological Survey field parties from Nevada and California. They were found in the Pogonip limestone (Ordovician) of that region. Enough material had accumulated to show that the gasteropod could not be assigned to any known genus, but despite the fact that 30 or 40 specimens were available for study it was not felt that a description of the form was warranted. During the past field season C. R. Longwell, in southern Nevada and the author in central Nevada, made special efforts to collect good specimens of this interesting gasteropod. It is now felt that as good material is at hand as is likely to be found.

The gasteropod which is here described as *Mitrospira longwelli* has a wide distribution in the Great Basin region and is highly characteristic of a fairly narrow zone within the upper portion of the Pogonip. This is of Chazyan age and underlies a fauna closely comparable with zone N of the Chazyan of Canada. Where found the gasteropod is usually present in great numbers. Unfortunately it usually occurs in massive ledges of hard limestone, where thousands of weathered sections may be seen but where it is almost impossible to secure good specimens. The shell of the gasteropod is thick and is replaced by crystalline calcite that shatters badly, leaving only the exfoliated cast of the interior. In thinner-bedded limestones specimens as a rule are imperfect, due to weathering.

MITROSPIRA, new genus

The genus, as here defined, contains the single species *Mitrospira longwelli*, new species. Of this form by careful selection from a large number of specimens enough material has been prepared to show all essential structures in detail. It was found in the preparation of the material that grinding away the matrix was the only satisfactory method.

In order to make clear the following description it should be explained that *Mitrospira* is assumed to have normal dextral coiling. *Mitrospira* seems in fact to be an everted *Maclurites*, the flat lower surface of that genus being produced into a spire. It is tentatively held, therefore, that the spire of *Mitrospira* is the lower and the umbilicated side the upper surface of the shell.

The genus as known is characterized by individuals of large size. The lower side of the shell is produced into a fairly high spire, while the upper side shows a wide umbilicus. The relative height of the spire is variable, due to greater or less overlap of the whorls on those preceding. The umbilicus is wide and open, the tubular cavity extending to the apex of the spire. The upper free margin of the whorls next the umbilicus is subangular. As shown by the growth lines and a fairly perfect aperture, this keel marks the apex of a deep reentrant notch. The keel is then considered the probable equivalent of the notch keel of the typical Pleurotomarids. An interesting feature of the genus is a progressive filling of the living chamber by secondary deposits of lime. This is noted in the description of the species and shows clearly in the section figured. The deposit is closely comparable with the secondary filling of the older camerae of certain cephalopods.

It is here considered probable that *Mitrospira* is a direct derivative of *Maclurites*, having originated as an abrupt saltation. Both in the preceding portion of the Pogonip, of approximately Beekmantown age, and the Chazyan portion *Maclurites* and its congeners are abundant not only in numbers but also in diversity of specific and possibly generic types. No antecedent form to *Mitrospira* has been found, which, though negative evidence, is suggestive. On the other hand, the considerable range in height of spire to be seen in *Mitrospira*, coupled with its essential identity of structure with *Maclurites*, indicates a close genetic relationship with the latter genus. A tendency toward the formation of a spire is shown, so far as known, only on this horizon, except as noted later in the very late Ordovician. In the Pogonip one species of *Maclurites* at times shows a very slight eversion of the whorls, giving a slightly convex outline to the lower surface. It is of interest to note that otherwise no such tendency toward spire formation has been seen on examination of large numbers of *Maclurites* from the Middle and Upper Ordovician, except in the genus *Palliseria*.

The only other known gasteropod with which *Mitrospira* may be compared is *Palliseria* Wilson.[1] This genus is compared with *Maclu-*

[1] Wilson, Alice E., A new genus and a new species of gasteropod from the Upper Ordovician of British Columbia: Canadian Field-Naturalist, vol. 38, No. 8, pp. 150–151, October, 1924.

rina by Wilson but does not seem to be a direct derivative. It seems more probable that it was derived from a *Maclurites* like form by way of some such intermediate stage as *Mitrospira* or belongs to some other genetic line. In section an adult whorl of *Palliseria* has a subquadrate or irregularly polygonal outline, Wilson describing the form as having " six outstanding angles formed by the carinae." Besides differing from *Mitrospira* in the sharply angulated mature whorl, *Palliseria* is easily distinguished by its slightly developed apertural notch. In this connection it is of interest to note two racial groups within the genus *Maclurites* as now defined. In one there is a pronounced apertural notch, and in the other the notch is inconspicuous or wanting. It may well be that two distinct generic types are represented, but as a rule the material available for study does not show the apertural margin or the growth lines clearly, and at present it would be inadvisable to make such a separation. *Palliseria* is found well up in the Upper Ordovician.

Genotype.—The genotype and at present only known species is *Mitrospira longwelli*, new species.

Horizon and locality.—The genus is known in the upper portion of the Pogonip limestone (of Chazyan age) in Nevada and California. Dr. E. O. Ulrich informs me that he has at least two species of *Mitrospira*, one from Canada and another from Oklahoma. The Oklahoma species occurs in the lower part of the Simpson formation. At Phillipsburg, Canada, a species has been collected in beds considered by Ulrich as correlating with the uppermost Beekmantown beds as shown at Fort Cassin, or possibly of even later age.

MITROSPIRA LONGWELLI, new species

This species attains a very large size as compared with most gasteropods of equivalent age. An adult individual but not of maximum size has a height of 55 millimeters and a breadth of not less than 80 millimeters. An adult individual has from seven to eight whorls that increase very rapidly in size from the apex to the aperture. In the specimen noted above the whorl at the aperture has a height of approximately 40 millimeters and a maximum breadth of 20 millimeters. The lower side of the shell has typically a broadly expanding subconical profile. The height of the spire is somewhat variable, due to a greater or less amount of overlap of the whorls on those preceding. On Plate 3, Figure 5, is shown the highest spired specimen seen, in which the height and breadth of the specimen are approximately equal. This specimen is an extreme variant and is doubtfully referred to *M. longwelli.*

The whorls, of which there are seven to eight in an average adult specimen, increase rapidly in size with the growth of the animal.

Typically each whorl overlaps the preceding to fully two-thirds its height. By secondary deposits of lime the amount of overlap is made even greater in the older portion of the shell. In section the whorl is an asymmetrically compressed oval with the long axis at an angle of about 45° to the axis of the shell. The inner surface, next the umbilicus, is nearly straight and vertical. At the upper inner shoulder a fairly sharp angular keel is formed. The outline of the whorl in section is well shown in the illustrations.

The surface of the shell when well preserved is marked by fine rounded closely spaced growth lines. The course of these lines can not well be followed in a single specimen, but by using several individuals and a carefully prepared aperture in one specimen it can be worked out in detail. The apertural margin that is figured here was prepared by grinding away the matrix without cutting into the shell. Some of the margin may have been broken away before fossilization, but the aperture as illustrated is, I believe, essentially the true one. It has been carefully checked by other specimens that show the margin in part. Starting at the lower suture the growth line on an adult whorl trends slightly backward and then carries forward in a smooth curve to the periphery of the whorl. Here a forward projected saddle is outlined. The growth line now swings backward in a sweeping curve, which becomes less accentuated in the upper fifth of the whorl as it approaches the angular keel. Passing over the keel the line carries forward a little from the vertical to the inner suture. This gives us a very deep asymmetrical apertural notch with the apex at the keel. These structures may clearly be seen in the illustrations.

The central tubular cavity as noted above extends to the apex of the spire. Each whorl is stepped outward slightly in relation to the one preceding, giving an ever-widening cavity with advancing age. In an adult individual, the outside measurements of which have been given above, the umbilicus has a width in excess of 25 millimeters.

An interesting feature shown by vertical sections is that the whorls were progressively filled with secondary deposits of lime during the life of the animal. In the section figured it will be noted that only the two latest whorls show an inner cavity, the size of which decreases rapidly as one goes backward. The older whorls are solidly filled. Where there is still an opening in the whorl the margin of the cavity shows as a smooth sharply defined wall.

Horizon and localities.—Mitrospira longwelli where found and the stratigraphic relationships known occurs in the lower portion of the Chazyan part of the Pogonip limestone. As noted above, it

directly underlies a fauna which seems to correlate closely with zone N of the Chazyan section of Canada. Specimens have been collected in the Las Vegas quadrangle, southern Nevada; Inyo and Panamint Ranges, Calif.; and Toyquima, Monitor, and Antelope Ranges of central Nevada.

Types.—The cotypes are in the collections of the United States National Museum No. 80840, 80847, 80848. The specimens from the Las Vegas quadrangle were collected by C. R. Longwell. Those from the Toyquima and Monitor Ranges were collected by Edwin Kirk. Specimen, Figures 1, 2, Plate 1, and Figures 1, 2, Plate 2, specimen, Figure 3, Plate 1, and specimen, Figure 5, Plate 3, were collected in the Las Vegas quadrangle, Nevada, by Prof. C. R. Longwell. The exact locality is "Summit on Alamo road south of Sheep Playa. Outcrops just west of summit." Specimen, Figure 4, Plate 3, was collected by Edwin Kirk on the east front of the Toyquima (Toiquima) Range, Nev., near the mouth of a canyon variously known as Ike's or McMonigle's. This is in the Lowry Peak quadrangle. Specimen, Figures 1, 2, 3, Plate 3, was collected by Edwin Kirk on the east front of the Monitor Range facing Antelope Valley about 5 miles south of the mouth of Ryegrass Canyon, Lowry Peak quadrangle, Nevada.

EXPLANATION OF PLATES

PLATE 1

Mitrospira longwelli, new genus and species

FIGURE 1. Lateral view of large specimen. The growth lines to the right near the aperture are abnormally developed and probably indicate a gerontic individual. The apparent angulation at the periphery of the last whorl is due to weathering.

2. Lateral apertural view of same specimen.

3. Vertical section. The apex of the spire has been removed by weathering. Note the progressive filling of the living chamber by secondary deposits of lime. The interruption in the last whorl, to the left, is due to the fact that the section cuts through the apertural notch.

PLATE 2

Mitrospira longwelli, new genus and species

FIGURE 1. Upper view of same specimen shown in Plate 1, Figures 1, 2, showing the wide umbilicus.

2. Lower, apical view of same specimen.

PLATE 3

Mitrospira longwelli, new genus and species

FIGURES 1, 2, 3. Various views of the aperture. Figure 1, looking directly into the aperture. Figure 2, lateral view showing the sinuous outline of the outer margin of the aperture and the pronounced retral swing to the notch keel. Figure 3, the aperture as viewed from the upper (umbilicated) side.

4. View of specimen with the earlier whorls fairly well preserved, showing the apex of the spire and the ornamentation. The outer whorl of the specimen has been blocked out, giving the outer whorl as shown not its true width but the width visible when overlapped by the later whorl.

5. Lateral view of badly exfoliated specimen, doubtfully referred to this species. The specimen shows the most extreme relative height of spire seen.

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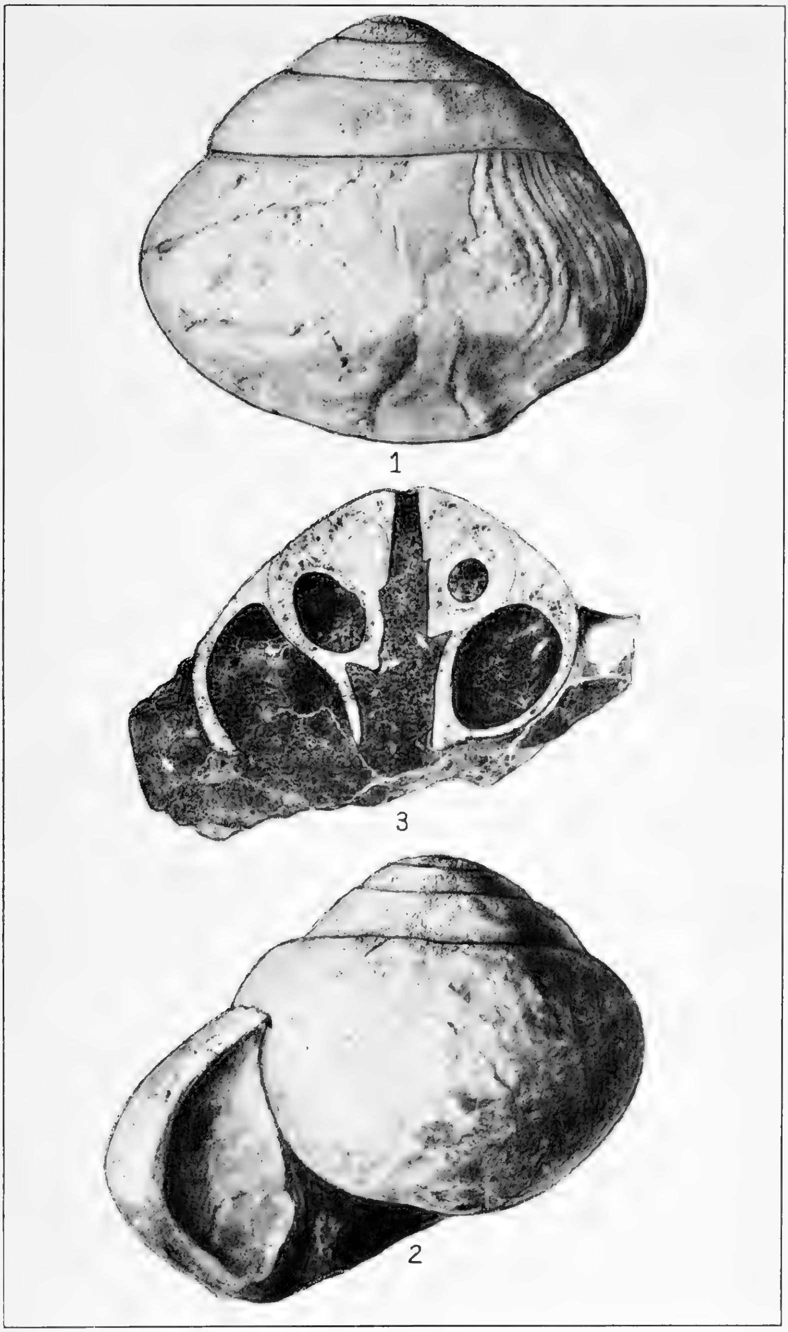
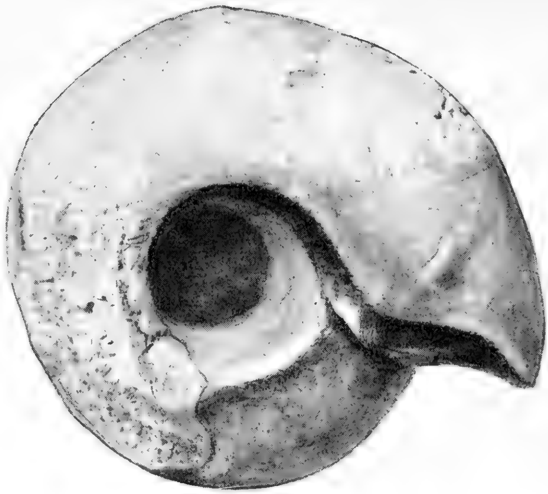


MITROSPIRA LONGWELLI; NEW GENUS AND SPECIES

FOR EXPLANATION OF PLATE SEE PAGE 5



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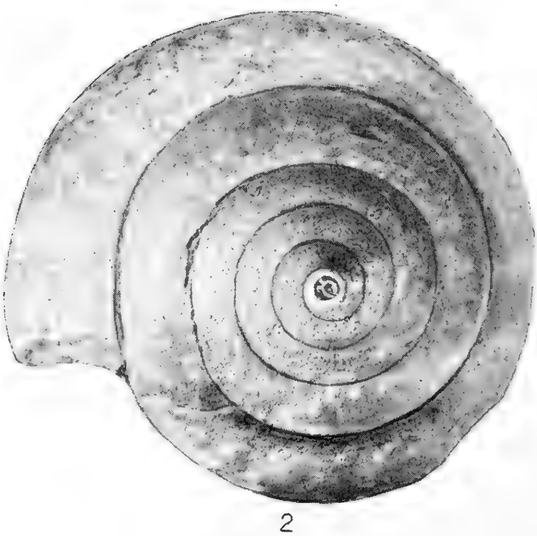

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MITROSPIRA LONGWELLI, NEW GENUS AND SPECIES

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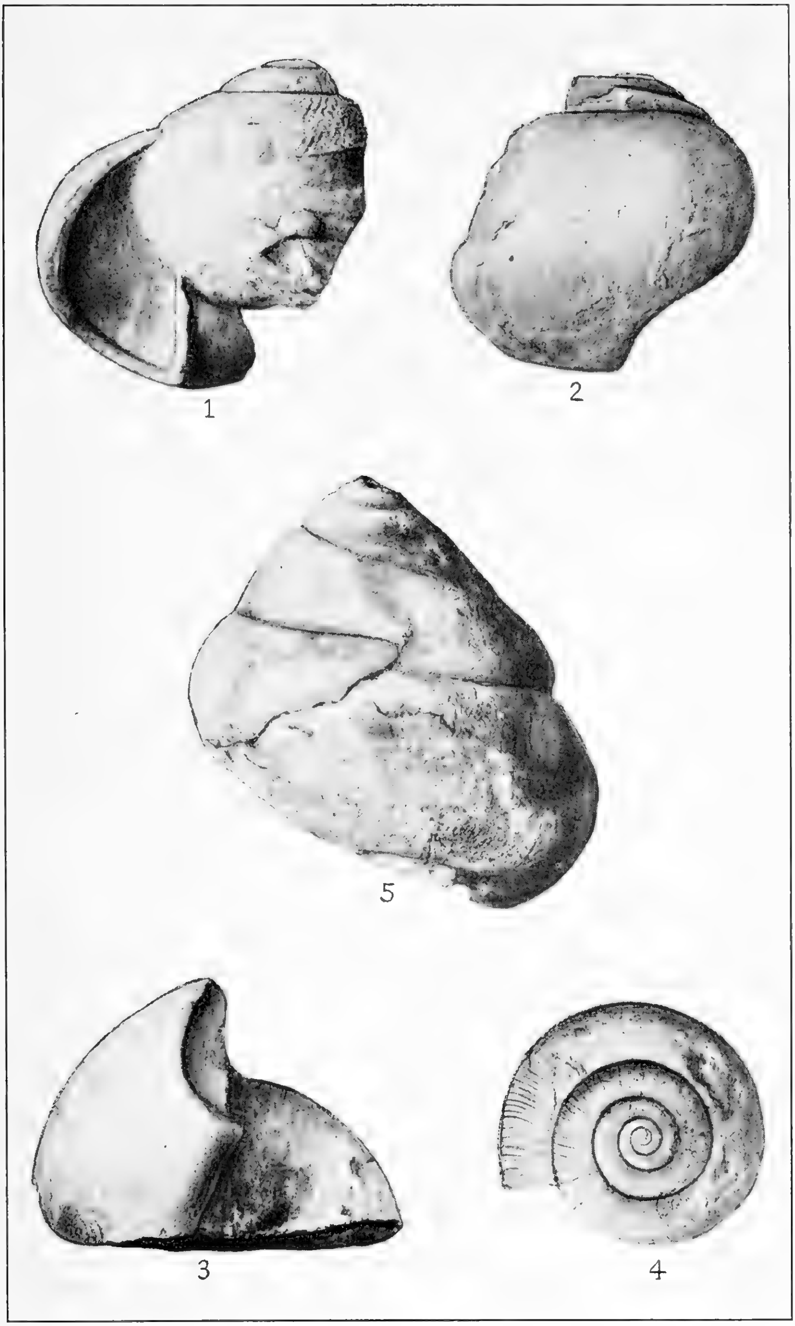

MITROSPIRA LONGWELLI, NEW GENUS AND SPECIES

FOR EXPLANATION OF PLATE SEE PAGE 6

A NEW FOSSIL CORAL FROM THE CRETACEOUS OF TEXAS

By J. Edward Hoffmeister
Of the University of Rochester, New York

The species *Hindeastraea discoidea* was made the type of a new genus *Hindeastraea* by White.[1] The type (see pl. 2, figs. 1 and 1*a* for paratype) was reported to have been obtained from the Ripley (Navarro) formation near Terrell, Kaufman County, Tex. White compared *Hindeastraea* to *Isastrea* Milne Edwards and Haime and said the latter differed in having a massive growth form, in its more numerous dissepiments, and in the less distinct boundaries formed by the walls between the calices.

Dr. L. W. Stephenson, of the United States Geological Survey, turned over to me a small series of specimens collected by Mr. C. H. Dane (U. S. Geol. Surv. Coll. No. 13837) from a thin bed in the Wolfe City sand of the Taylor marl about 1 mile N. 30° W. of Farmersville, Collin County, Tex. These, together with a specimen from the same locality collected by Mr. A. H. Kimzey (U. S. Geol. Surv. Coll. No. 13781), throw additional light on the structure and growth form of the genus.

These specimens have a massive, irregular growth form and in this way differ from *Hindeastraea discoidea.* However, the calicular characteristics are so nearly identical that it is probable the specimens describe by White represent merely the early growth stages of the species, and that as development progresses the corallum becomes massive. Until specimens are obtained, however, which show the actual transition between the two forms I am keeping them separate and placing the massive ones in a new species, *Hindeastraea collinensis.* The following description is of the specimen collected by Mr. A. H. Kimzey, which is No. 73608, United States National Museum, and is here designated the type.

[1] White, C. A., Hindeastraea, a new generic form of Cretaceous Astraeidae, Geol. Mag. London, dec. 3, vol. 5, p. 363, figs. 1–5, 1888.

HINDEASTRAEA COLLINENSIS, new species

Plate 1, Figures 1, 1*a*, 2, 2*a*; Plate 2, Figures 2, 3, and 4

Corrallum an irregular flattened frond broken at base, with calices on all sides. Length, 103 millimeters; width, 36 millimeters at base, becoming narrower higher up; thickness, 15 millimeters.

Corallite separated by distinct walls about 0.5 millimeter wide and as much high, which inclose polygonal calices, usually five or six sided. The material of the corallum is so recrystallized that it is difficult to tell much concerning the structure of the wall. Judging from what could be seen in some poor sections, however, and also from the fact that the septa are not crowded a true theca seems to be present.

Diameter of calices about 8 millimeters, smaller on the edges of the frond and near the top than on the flattened sides. Some have a diameter of only 4 or 5 millimeters and others as much as 11 millimeters. Calices shallow, only 1 to 2 millimeters deep at the subcircular fossa above the columella and less than that toward walls.

The septa are in three complete cycles. Those of the first two cycles are subequal and join the columella. The septa of the third cycle bend and join those of the second just before the columella is reached. All 24 septa are of about the same thickness; thicker near wall where some measure as much as 1 millimeter and becoming thinner toward center of calice. Septal edges depressed slightly at intercorallite wall, then rise somewhat toward center to form a subcircular ridge before plunging down relatively steeply to the columella. The arrangement of the septa to form this ridge, together with what seems to be a concentration of dissepiments here, gives it the appearance of an inner wall. Septa seems to be imperforate; faces with granulations which are in most places arranged in vertical rows indicating probably the courses of the trabeculae; edges dentate with dentations continuous with granular rows on faces.

Columella spongy, made of fused ends of septa; about 2 millimeters in diameter in well-developed calices.

Reproduction by intercalicular gemmation, mainly at the edges of the corallum.

The growth form of most of the other specimens in the suite is also massive with irregular surfaces and with corallites on both sides and edges. Some of these have the intercorrallite walls and the septal edges which adjoin them worn away, which accentuates the inner raised rim of the columella fossa (see pl. 2, figs. 2, 3, and 4). Others show no evidence whatever of this rim.

Holotype and paratypes.—Cat. Nos. 73608, 73609, U.S.N.M.

The type specimens of *Hindeastraea discoidea* White are similar to this species except in growth form. The septa are the same in

number, arrangement, and appearance. In only one calice are there as many as 26 septa. The septa are not as thick as those usually found on the type but correspond in this respect to some of the other specimens.

Grateful acknowledgment is made of the aid given by Dr. T. Wayland Vaughan in the description of this coral.

EXPLANATION OF PLATES

(All specimens figured in Plates 1 and 2 are from the vicinity of Farmersville, Collin County, Tex.)

PLATE 1

Hindeastraea collinensis Hoffmeister

FIGURE 1. The type, natural size. U. S. Nat. Mus. Cat. No. 73608.
1*a*. The type, calices × 2.
2. A typical specimen, natural size. U. S. Nat. Mus. Cat. No. 73609.
2*a*. Same specimen, calices × 2.

PLATE 2

FIGURE 1. *Hindeastraea discoidea* White. Paratype. Calices × 4. U. S. Nat. Mus. Cat. No. 19166.
1*a*. *Hindeastraea discoidea* White. Paratype. Bottom view × 4. U. S. Nat. Mus. Cat. No. 19166.
2. *Hindeastraea collinensis* Hoffmeister. A specimen showing variation in calicular arrangement. U. S. Nat. Mus. Cat. No. 73609.
3. *Hindeastraea collinensis* Hoffmeister. Specimen with irregular growth form. U. S. Nat. Mus. Cat. No. 73609.
4. *Hindeastraea collinensis* Hoffmeister. A specimen showing calices × 4. U. S. Nat. Mus. Cat. No. 73609.

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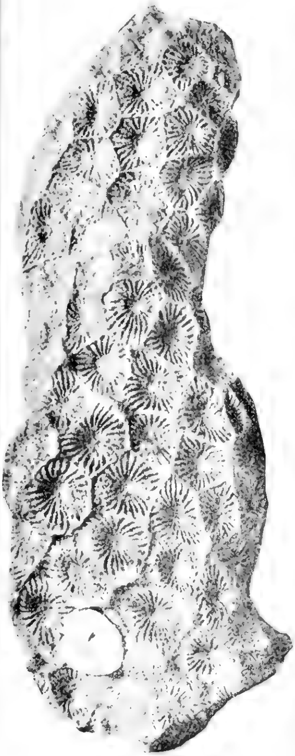

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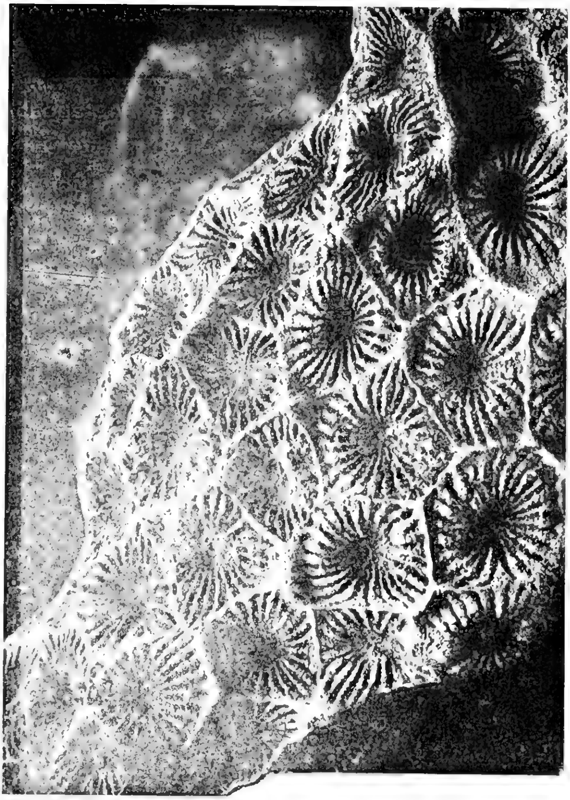
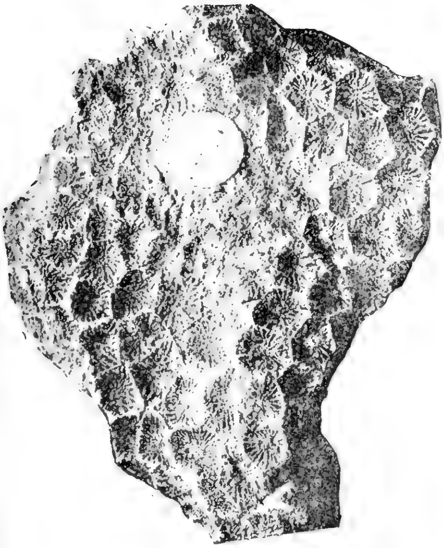


1*a*



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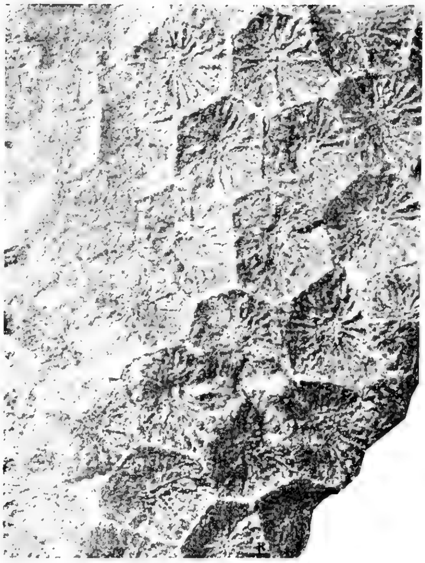
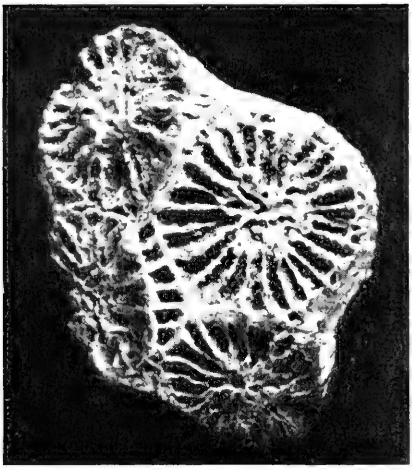


2*a*

CRETACEOUS CORALS FROM TEXAS

FOR EXPLANATION OF PLATE SEE PAGE 3



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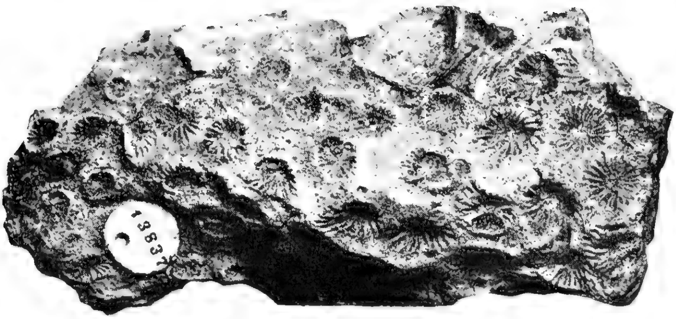
1*a*



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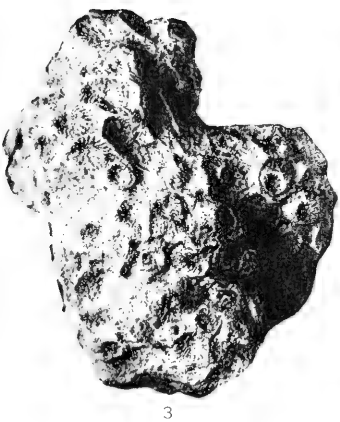

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CRETACEOUS CORALS FROM TEXAS

FOR EXPLANATION OF PLATE SEE PAGE 3

A SYSTEMATIC CLASSIFICATION FOR THE BIRDS OF THE WORLD

By Alexander Wetmore

Assistant Secretary, Smithsonian Institution

Since preparing a classification of North American birds[1] in collaboration with the late W. deW. Miller, of the American Museum of Natural History, for use in the fourth edition of the official Check-list of the American Ornithologists' Union, now in course of publication, the writer has continued investigations in this interesting subject, with the result that he here offers an arrangement of the known birds of the world, living and fossil, in accordance with his present understanding of their relationships. The work of Hans Gadow has been taken as a starting point, and such changes have been incorporated as seem justified from personal research or from the investigations of others. In general, only such variations from the current order have been accepted as seem to be firmly established. Where doubt seems to attach to any proposition, the older classification has been followed; so the following scheme presents a conservative arrangement so far as possible. The list is complete for all categories down to families. Attempt has been made to follow a definite terminology for the various groups, so that there may be no misunderstanding of their proper rank.

Class Aves.
- Subclass Archaeornithes.
  - Order Archaeopterygiformes.
    - Family Archaeopterygidae, *Archaeopteryx*, *Archaeornis* (fossil).
- Subclass Neornithes.
  - Superorder Odontognathae.
    - Order Hesperornithiformes.
      - Family Hesperornithidae, *Hesperornis*, *Hargeria* (fossil).
      - Baptornithidae, *Baptornis* (fossil).
      - Enaliornithidae,[2] *Enaliornis* (fossil).
    - Order Ichthyornithiformes.
      - Family Ichthyornithidae, *Ichthyornis* (fossil).

[1] See Auk, 1926, 337–346.
[2] Position provisional.

Superorder Palaegnathae.
- Order Struthioniformes.
  - Family Struthionidae, Ostriches.
- Order Rheiformes.
  - Family Rheidae, Rheas.
- Order Casuariiformes.
  - Family Casuariidae, Cassowaries.
    - Dromiceiidae, Emus.
    - Dromornithidae, *Dromornis* (fossil).
- Order Dinornithiformes.
  - Family Dinornithidae, Moas (extinct).
- Order Æpyornithiformes.
  - Family Æpyornithidae, *Æpyornis* (extinct).
- Order Apterygiformes.
  - Family Apterygidae, Kiwis.
- Order Tinamiformes.
  - Family Tinamidae, Tinamous.

Superorder Neognathae.
- Order Sphenisciformes.
  - Family Spheniscidae, Penguins.
    - Cladornithidae, *Cladornis* (fossil).
- Order Gaviiformes.
  - Family Gaviidae, Loons.
- Order Colymbiformes.
  - Family Colymbidae, Grebes.
- Order Procellariiformes.
  - Family Diomedeidae, Albatrosses.
    - Procellariidae, Shearwaters, Fulmars.
    - Hydrobatidae, Small Petrels.
    - Pelecanoididae, Diving Petrels.
- Order Pelecaniformes.
  - Suborder Phaëthontes.
    - Family Phaëthontidae, Tropic-birds.
  - Suborder Pelecani.
    - Superfamily Pelecanides.
      - Family Pelecanidae, Pelicans.
        - Cyphornithidae, *Cyphornis*, *Palaeochenoides* (fossil).
    - Superfamily Sulides.
      - Family Pelagornithidae, *Pelagornis* (fossil).
        - Sulidae, Boobies, Gannets.
        - Phalacrocoracidae, Cormorants.
        - Anhingidae, Snake-birds.
  - Suborder Fregatae.
    - Family Fregatidae, Man-o'war Birds.

Suborder Odontopteryges.
Family Odontopterygidae, *Odontopteryx* (fossil).
Order Ciconiiformes.
Suborder Ardeae.
Family Ardeidae, Herons, Bitterns.
Cochleariidae, Boat-billed Herons.
Suborder Balaenicipites.
Family Balaenicipitidae, Shoe-bills.
Suborder Ciconiae.
Superfamily Scopides.
Family Scopidae, Hammerheads.
Superfamily Ciconiides.
Family Ciconiidae, Storks, Jabirus.
Superfamily Threskiornithides.
Family Threskiornithidae, Ibises, Spoonbills.
Suborder Phoenicopteri.
Family Phoenicopteridae, Flamingos.
Order Anseriformes.
Suborder Anhimae.
Family Anhimidae, Screamers.
Suborder Anseres.
Family Anatidae, Ducks, Geese, Swans.
Order Falconiformes.
Suborder Cathartae.
Family Cathartidae, New World Vultures.
Teratornithidae, *Teratornis* (fossil).
Suborder Falcones.
Family Sagittariidae, Secretary-birds.
Accipitridae, Hawks, Old World Vultures, Harriers, Ospreys.
Falconidae, Falcons, Caracaras.
Order Galliformes.
Suborder Galli.
Superfamily Cracides.
Family Megapodidae, Megapodes.
Gallinuloididae, *Gallinuloides* (fossil).
Cracidae, Curassows, Guans, Chachalacas.
Superfamily Phasianides.
Family Tetraonidae, Grouse.
Perdicidae, Quails.
Phasianidae, Pheasants, Peacocks.
Numididae, Guinea-fowl.
Meleagridae, Turkeys.
Suborder Opisthocomi.
Family Opisthocomidae, Hoatzins.

Order Gruiformes.
 Suborder Mesoenatides.
  Family Mesoenatidae, Roatelos, Monias.
 Suborder Turnices.
  Family Turnicidae, Bustard-Quails.
   Pedionomidae, Collared Hemipodes.
 Suborder Grues.
  Superfamily Gruides.
   Family Gruidae, Cranes.
    Aramidae, Limpkins.
    Psophiidae, Trumpeters.
  Superfamily Rallides.
   Family Rallidae, Rails, Coots, Gallinules.
 Suborder Heliornithes.
  Family Heliornithidae, Sun-Grebes.
 Suborder Rhynocheti.
  Family Rhynochetidae, Kagus.
 Suborder Eurypygae.
  Family Eurypygidae, Sun-Bitterns.
 Suborder Phororhaci.
  Family Phororhacidae, *Phororhacos* (fossil).
 Suborder Cariamae.
  Family Hermosiornidae, *Hermosiornis* (fossil).
   Cariamidae, Cariamas.
 Suborder Otides.
  Family Otididae, Bustards.
Order Diatrymiformes.
  Family Diatrymidae, *Diatryma* (fossil).
Order Charadriiformes.
 Suborder Charadrii.
  Superfamily Jacanides.
   Family Jacanidae, Jacanas.
  Superfamily Charadriides.
   Family Haematopodidae, Oyster-catchers.
    Charadriidae, Plovers, Turnstones, Surf-birds.
    Scolopacidae, Snipe, Woodcock, Sandpipers.
    Recurvirostridae, Avocets, Stilts.
    Presbyornithidae, *Presbyornis* (fossil).
    Phalaropodidae, Phalaropes.
  Superfamily Dromades.
   Family Dromadidae, Crab-plovers.
  Superfamily Œdicnemides.
   Family Œdicnemidae, Thick-knees.

Superfamily Glareolides.
Family Glareolidae, Pratincoles, Coursers.
Superfamily Thinocorides.
Family Thinocoridae, Seed-snipe.
Superfamily Chionides.
Family Chionidae, Sheath-bills.
Suborder Lari.
Family Stercorariidae, Skuas, Jaegers.
Laridae, Gulls, Terns.
Rynchopidae, Skimmers.
Suborder Alcae.
Family Alcidae, Auks, Auklets, Murres.
Order Columbiformes.
Suborder Pterocletes.
Family Pteroclidae, Sand-Grouse.
Suborder Columbae.
Family Raphidae, Dodos, Solitaires.
Columbidae, Pigeons, Doves.
Order Cuculiformes.
Suborder Musophagi.
Family Musophagidae, Plaintain-eaters.
Suborder Cuculi.
Family Cuculidae, Cuckoos, Roadrunners, Anis.
Order Psittaciformes.
Family Loriidae, Lories.
Psittacidae, Parrots, Macaws.
Order Strigiformes.
Family Tytonidae, Barn-owls.
Strigidae, Owls.
Order Caprimulgiformes.
Suborder Steatornithes.
Family Steatornithidae, Oil-birds.
Suborder Caprimulgi.
Family Podargidae, Frogmouths.
Nyctibiidae, Potoos.
Ægothelidae, Owlet-Frogmouths.
Caprimulgidae, Goatsuckers.
Order Micropodiformes.
Suborder Micropodii.
Family Micropodidae, Swifts.
Macropterygidae, Crested Swifts.
Suborder Trochili.
Family Trochilidae, Hummingbirds.
Order Coliiformes.
Family Coliidae, Colies.

Order Trogoniformes.
- Family Trogonidae, Trogons.

Order Coraciiformes.
- Suborder Alcedines.
  - Superfamily Alcedinides.
    - Family Alcedinidae, Kingfishers.
  - Superfamily Todides.
    - Family Todidae, Todies.
  - Superfamily Momotides.
    - Family Momotidae, Motomots.
- Suborder Meropes.
  - Family Meropidae, Bee-eaters.
- Suborder Coracii.
  - Family Coraciidae, Rollers.
  - Leptosomatidae, Ground-rollers.
  - Upupidae, Hoopoes.
  - Phoeniculidae, Wood-hoopoes.
- Suborder Bucerotes.
  - Family Bucerotidae, Hornbills.

Order Piciformes.
- Suborder Galbulae.
  - Superfamily Galbulides.
    - Family Galbulidae, Jacamars.
    - Bucconidae, Puff-birds.
  - Superfamily Capitonides.
    - Family Capitonidae, Barbets.
    - Indicatoridae, Honey-guides.
  - Superfamily Rhamphastides.
    - Family Rhamphastidae, Toucans.
- Suborder Pici.
  - Family Picidae, Woodpeckers, Piculets.

Order Passeriformes.
- Suborder Eurylaimi.
  - Family Eurylaimidae, Broadbills.
- Suborder Tyranni.
  - Superfamily Furnariides.
    - Family Dendrocolaptidae, Wood-hewers.
    - Furnariidae, Ovenbirds.
    - Formicariidae, Ant-thrushes.
    - Conopophagidae, Ant-pipits.
    - Rhinocryptidae, Tapaculos.

Superfamily Tyrannides.
Family Cotingidae, Cotingas.
Pipridae, Manakins.
Tyrannidae, New World Flycatchers.
Oxyruncidae, Sharp-bills.
Phytotomidae, Plant-cutters.
Pittidae, Pittas.
Xenicidae, New Zealand Wrens.
Philepittidae, Asities.
Suborder Menurae.
Family Menuridae, Lyre-birds.
Atrichornithidae, Scrub-birds.
Suborder Oscines.
Family Alaudidae, Larks.
Palaeospizidae, *Palaeospiza* (fossil).
Hirundinidae, Swallows.
Campephagidae, Cuckoo-shrikes.
Dicruridae, Drongos.
Oriolidae, Old World Orioles.
Corvidae, Crows, Magpies, Jays.
Ptilinorhynchidae, Bower-birds.
Paradiseidae, Birds of Paradise.
Paridae, Titmice.
Sittidae, Nuthatches.
Hyposittidae, Coral-billed Nuthatches.
Certhiidae, Creepers.
Chamaeidae, Wren-tits.
Timeliidae, Babbling Thrushes.
Pycnonotidae, Bulbuls.
Cinclidae, Dippers.
Troglodytidae, Wrens.
Mimidae, Thrashers, Mockingbirds.
Turdidae, Thrushes.
Zeledoniidae, Wren-thrushes.
Paramythiidae, *Paramythia.*
Sylviidae, Old World Warblers.
Regulidae, Kinglets.
Muscicapidae, Old World Flycatchers.
Motacillidae, Wagtails, Pipits.
Enicuridae, Fork-tails.
Bombycillidae, Waxwings.
Ptilogonatidae, Silky Flycatchers.
Dulidae, Palm-chats.
Artamidae, Wood-swallows.

Family Vangidae, Vanga Shrikes.
Laniidae, Shrikes.
Prionopidae, Wood-shrikes.
Aërocharidae, Helmet-birds.
Cyclarhidae, Pepper-shrikes.
Vireolaniidae, Shrike-Vireos.
Sturnidae, Starlings.
Graculidae, Glossy Starlings.
Meliphagidae, Honey-eaters.
Nectariniidae, Sun-birds.
Dicaeidae, Flower-peckers.
Zosteropidae, White-eyes.
Vireonidae, Vireos.
Coerebidae, Honey-creepers.
Drepanididae, Hawaiian Honey-creepers.
Mniotiltidae, Wood Warblers.
Ploceidae, Weaver-finches.
Icteridae, Blackbirds, Troupials.
Procniatidae, Swallow-Tanagers.
Thraupidae, Tanagers.
Catamblyrhynchidae, Plush-capped Finches.
Fringillidae, Grosbeaks, Finches, Buntings.

SUPPOSED FOSSIL FAMILIES OF UNCERTAIN SYSTEMATIC POSITION

Gastornithidae, *Gastornis.*
Opisthodactylidae, *Opisthodactylus.*

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NEW SPECIES OF ICHNEUMON-FLIES AND TAXONOMIC NOTES

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The following pages contain the descriptions of new species of Ichneumonidae, Braconidae, and Aulacidae from the Nearctic and oriental zoological regions, together with notes on previously described species and genera and the proposal of a new generic name for a preoccupied name.

Family ICHNEUMONIDAE

AMBLYTELES VELOX (Cresson) (new combination)

Ichneumon velox Cresson, Proc. Ent. Soc. Phila., vol. 3, 1864, p. 185; Trans. Amer. Ent. Soc., vol. 6, 1877, p. 178.—Provancher, Faune Ent. Can., Hym., 1883, p. 287; female.

Ichneumon puerilis Cresson, Trans. Amer. Ent. Soc., vol. 1, 1867–8, p. 296; vol. 6, 1877, p. 158.—Provancher, Faune Ent. Can., Hym., 1883, p. 274; male. (New synonymy.)

Ichneumon occidentalis Harrington, Can. Ent., vol. 26, 1894, p. 210, female. (New synonymy.)

Ichneumon mellicoxus Provancher, Nat. Can., vol. 7, 1875, p. 48, male. (New synonymy.)

Phygadeuon apicatus Provancher, Nat. Can., vol. 7, 1875, p. 180, female.

Phygadeuon cressoni Provancher, Nat. Can., vol. 8, 1876, p. 318, female.

The synonymy of the two Cresson species is based on a series including both sexes reared by Karl Schedl from the hemlock looper in September, 1928, at Footes Bay, Ontario. The synonymy of *Ichneumon occidentalis* Harrington is based on a homotype (Gahan), which was also compared by Gahan with the types of *Phygadeuon apicatus* Provancher and *P. cressoni* Provancher, which two species were synonymized by Provancher himself. Provancher also synonymized his *Ichneumon mellicoxus* with *I. puerilis* Cresson.

ANISOBAS TEXENSIS (Ashmead) (new combination)

Cryptus texensis Ashmead, Proc. U. S. Nat. Mus., vol. 12, 1890, p. 410.

The type is female, not male as stated by Ashmead. There is also a male from Cypress Mills, Tex., which differs in no way except sexually from the type.

The species is very close to *A*, *nearcticus* Cushman; perhaps the two are the same, but both the Texan specimens have the fourth tergite broadly white margined and there are minor differences in sculpture and venation.

CRYPTUS PAITENSIS (Cockerell) (new combination)

Amblyteles paitensis Cockerell, Entomologist, vol. 60, 1927, p. 158.

The male holotype of this species has been presented by its author to the National Museum and has been listed as Cat. No. 41588, U.S.N.M.

It differs from typical *Cryptus* Fabricius only in lacking the apical carina of the propodeum, this being represented only by small apophyses, and in having the propodeum behind the basal carina coarsely reticulate rugose.

The same sort of variation occurs in the Neotropical genus *Trachysphyrus* Haliday, which is really distinguishable from *Cryptus* only by the metallic blue, green, and copper colors exhibited by its species.

CHROMOCRYPTUS MESORUFUS, new species

Female.—Length 7.5 mm. Tips of antennae, right front tarsus, left middle leg except coxa, and apical joints of both hind tarsi missing.

Structurally much like the genotype, *Chromocryptus planosae* (Fitch) with the sculpture perhaps a little coarser, but very distinct in color.

Head black with following white markings: Orbits except narrow interruption in malar space, a sinuate mark across face, disk of clypeus and of mandible, and an incomplete annulus occupying the dorsal half of flagellar joints 7 to 9 and part of 6 and 10. Thorax black with white as follows: Anterior and humeral margins of pronotum; lines in notauli; basal part of scutellum, emarginated by anterior extension of apical black; postscutellum; tegulae and radices; spots on mesopleurum below both front and hind wings, along prepectal suture and above middle coxae; a longitudinal mark below sternaulus; apex of metapleurum; and two longitudinal marks on posterior face of propodeum including the apophyses; front and middle coxae and trochanters black and white, these legs otherwise ferruginous with tarsi infuscate; hind leg ferruginous, knee and apex of tibia infuscate, tarsus black with second and third joints and apex of first below, white; wings hyaline with blackish venation. Abdomen black with all tergites broadly margined with white, first segment furruginous.

Type locality.—Cuernavaca, Morelos, Mexico.

Type.—Cat. No. 41990, U.S.N.M.

One female reared by C. Chambert and received from Dr. Alfons Dampf, chief entomologist of Mexico. The host record is open to

doubt. The specimen is said to have been reared from either *Anastrepha ludens* Loew or *A. straita* Schiner.

RHEMBOBIUS ABDOMINALIS (Provancher) (new combination)

Phygadeuon abdominalis PROVANCHER, Nat. Can., vol. 6, 1874, p. 280; vol. 11, 1879, p. 73; Faune Ent. Can., Hym., 1883, p. 319; Addit. Faune Ent. Can., Hym., 1886, p. 46.

In the collection of the National Museum there are 14 females and 6 males as follows: 1 female, Quebec (homotype, Rohwer); 1 female, Hartford, Conn.; 6 females, Colorado, including 4 from El Paso County reared from decayed cottonwood; 5 females and 2 males, Puyallup and Sumner, Wash., reared from the bulb fly, *Merodon equestris* Fabricius; 1 female, Santa Cruz, Calif., reared from the smaller bulb fly, *Eumerus strigatus* Fallen; 1 male, Narrows, Mount Desert, Me. (C. W. Johnson, collector); 1 male, Westfield, N. Y. (R. A. Cushman, collector); and 2 males, Harney Peak and Waubay, S. Dak.

All of the specimens from Washington, the one from California, one from South Dakota, and all but one of the Colorado specimens differ from the typical form in having the hind femora and tibiae entirely red; the western females and one from Colorado differ further in the lack of the white antennal annulus, though a few show traces of white at the base of one or more joints; in the Colorado female that has the apices of the hind femur and tibia black the extent of black is reduced and in addition the front and middle femora are not at all black as in the typical form; the far western males also differ from the typical eastern form in their lack of white markings on the front and middle coxae and trochanters and in a reduction of the extent of white markings on the face, clypeus, and scape; one of the Dakota specimens is typical in these respects while the other is intermediate.

The species is very closely allied to the European *R. quadrispinus* (Gravenhorst), which, however, has the abdomen black beyond the third segment.

TRICHOCRYPTUS ATLANTICUS, new species

Very closely allied to *bicolor* Cushman, with the description of which it agrees except as follows:

Female.—Length 8 mm.; antennae 4.25, ovipositor sheath 2 mm.

Eyes not distinctly convergent below; propodeum in profile slightly convex above; petiolar area not distinctly shorter than combined areola and basal area. Scutellum white apically; tarsi infuscate.

Type locality.—Bladensburg, Md.

Type.—Cat. No. 41991, U.S.N.M.

One female taken June 23, 1916, by R. C. Shannon.

HEMITELES HUNGERFORDI, new species

In Foerster's key to the genera of the Hemiteloidae it runs directly to *Philonygmus* Foerster, a genus without included species; and agrees well with all characters except that the temples are rather strongly sloping.

Female.—Length 4.5 mm.; antennae 3.5 mm.

Head a little more than twice as broad as thick; temples convexly sloping, the convexity continuous with that of the eyes; temples, cheeks, and vertex behind ocelli shining and faintly alutaceous; frons opaque, with a distinct median groove; ocelli small, in diameter less than length of ocell-ocular line, which is about half as long as postocellar line; eyes slightly divergent below; face about twice as broad as long, opaque punctate; clypeus deeply separated from face, nearly as long as interfoveal line, apically, inflexed, truncate, more shining than face; malar space as long as basal width of mandible, antennae thickened beyond middle, flagellum 17-jointed, basal joints slender, subapical joints nearly twice as long as thick. Thorax neither stout nor slender; pronotum finely subopaquely punctate, with a deep transverse groove across collar; mesoscutum subopaque, notauli very deep, confluent posteriorly; scutellar fovea very deep, broad and foveolate; scutellum opaque, convex, without lateral carinae; mesopleurum and sternum very finely punctate, subopaque, sternauli sharply defined, speculum subpolished; metapleurum and propodeum very finely punctate opaque, areolation complete, carinae very strong, especially the apical carina, areola hexagonal, broader than long, spiracle very small round, midway between pleural and lateral carinae; legs slender, hind basitarsus fully twice as long as second joint, third and fifth joints subequal; stigma broad, radius beyond middle; radial cell short, not longer on metacarpus than stigma; areolet large, entirely open at apex; discocubitus broken; nervulus slightly postfurcal; postnervulus nearly straight with subdiscoideus slightly below middle; abscissula a half longer than intercubitella; nervellus broken slightly below middle. Abdomen, except first segment, polished, second tergite very faintly alutaceous; first segment in profile strongly curved, thicker in middle than at apex, from above scarcely more than twice as broad at apex as at base, spiracles in middle, lateral and dorsal carinae strong to apex, with a groove between dorsal carinae, dorsal surface subopaque, lateral surfaces opaque; abdomen beyond first segment broadly oval, epipleura very broad, inflexed; ovipositor sheath slender, about as long as first segment.

Black; wings hyaline with dark venation; mandibles reddish; legs, except coxae, testaceous, tarsi apically blackish.

Male.—Essentially like female, but more slender, second tergite more distinctly sculptured, and flagellum stout filiform, not thickened beyond middle.

Type locality.—Burt Lake, mouth of Maple River, Mich.

Host.—*Gyrinus* species (cocoon).

Type.—Cat. No. 41992, U.S.N.M.

Two females and three males reared by H. B. Hungerford, July 23–26, 1927.

This is the third ichneumonid parasite recorded from *Gyrinus*. The others are the European *Hemiteles argentatus* Gravenhorst (=*Hemiteles gyrini* Parfitt) and the American *Gausocentrus gyrini* Ashmead. The first is unknown to me but is amply distinct from *hungerfordi* in color and sculpture. The second, Davis has already indicated, belongs to the Hemitelini, though he assigned it to no genus. It is congeneric with *hungerfordi*, though amply distinct specifically. In *Hemiteles* Gravenhorst it is preoccupied by *gyrini* Parfitt. A new name is assigned to it below.

HEMITELES GYRINOPHAGUS, new name

Gausocentrus gyrini Ashmead, Can. Ent., 1894, p. 25 (not *Hemiteles gyrini* Parfitt).

(*Gausocentrus*) Hemitelini *gyrini* Davis, Trans. Amer. Ent. Soc., vol. 24, 1897, p. 342.

Genus MACROGROTEA Brethes

Macrogrotea Brethes, Rev. Chilena de Hist. Nat., vol. 20, 1916, p. 84. Type.—*Pimpla gayi* Spinola.

Labenidea Rohwer, Proc. U. S. Nat. Mus., vol. 57, 1920, p. 413. Type.—(*Grota superba* Schmiedeknecht)=*Macrogrotea gayi* (Spinola), according to Brethes (new synonymy).

METACOELUS CAVICOLA, new species

A typical *Metacoelus* Foerster with no apparent modification to adapt it for cave life unless the white ocelli be such.

In general form and structure it is very like *femoralis* (Geoffroy), but it is at once distinguishable by its largely black hind coxae and femora.

Female.—Length 7 mm.

Head in profile nearly equilaterally triangular, the combined face and clypeus moderately convex, protrusion of upper margin of face comprising about one-third total thickness of head; face densely punctate, clypeus more sparsely so; frons minutely opaquely punctuate, medially slightly elevated; diameter of lateral ocellus barely as long as ocell-ocular line; malar space fully twice basal width of mandible; antennae as long as combined length of head, thorax and first abdominal segment; flagellum tapering from base to apex, the apical joint less than half as thick as the basal; first joint nearly two-thirds as thick at apex as long, second and following joints transverse, middle

joints quadrate, subapical joints slightly longer than thick, apical joint distinctly elongate. Humeral margin of pronotum finely punctate, opaque; mesoscutum and scutellum shining, with rather coarse distinct punctures, notauli represented by deep pits anteriorly from which very faint impressions converge backward to a shallow median impression; thorax laterally mostly highly polished, anterior half of mesopleurum and mesosternum finely punctate; propodeum, except the polished areola, finely punctate, areola not separated from basal area, the combined area more than twice as long as broad at middle, where the costulae are received; hind femur hardly twice as long as deep. Abdomen very finely and rather densely punctate.

Black with cinereous pubescence, longest on face, sternum and coxae; mandibles, upper margin of face, and antennae ferruginous; front and middle legs reddish stramineous, middle coxae and femora more or less brownish; hind coxae except apex and femur except extremities black, hind leg otherwise testaceous; wings yellowish hyaline especially basad of stigma, where the venation is also yellow, stigma and apical venation brownish; venter pale brownish yellow; sheath of ovipositor whitish.

Type locality.—Batu Caves (Dark Cave), Selangor, Federated Malay States, 800 feet from entrance.

Type.—Cat. No. 41102, U.S.N.M.

Four females, all taken by C. Dover.

PANISCUS PLATYPES, new species

Remarkable chiefly for its very distinctly flattened tarsi. In my key to North American species [1] it runs best to *pallens* Cushman, but is distinctly larger, the abdomen and legs stouter, and the tarsi much more strongly flattened.

Female.—Length 18 mm., antennae (broken).

Temples rather strongly convex and only a little narrower than eyes; ocelli large and nearly contiguous with the eyes; face hardly as long as broad, fully a half broader than frons, minutely opaquely shagreened, sparsely punctate, strongly elevated medially; clypeus more than half as long as interfoveal line with basal groove arched above level of foveae, weakly emarginate at apex, weakly convex, sculptured as face but with punctures larger and sparser; malar space short but distinct; antennae broken, flagellum apparently tapering from base to apex, the twenty-second joint about twice as long as thick. Thorax very finely and densely punctate opaque, the pleura less densely so and shining; notauli long, shallow; scutellum margined to apex, the space between the carinae nearly two-thirds as broad at apex as at base; metapleurum finely striato-punctate; pro-

[1] Proc. U. S. Nat. Mus., vol. 64, Art. 20, 1924, p. 23.

podeum transversely striate, apophyses strong; areolet sessile, subquadrangular, second recurrent postfurcal with respect to second intercubitus, almost uniformly curved; nervulus postfurcal by hardly half its length; postnervulus broken slightly below upper third; nervellus broken at a right angle, upper abscissa three-fourths as long as lower; legs rather stout; hind femur four-fifths as long as tibia; tibiae sparsely spinose; tarsi stout, apical three joints strongly flattened, fifth joint of middle tarsus longer than third and only a little shorter than second; claws large with about 12 coarse teeth. Abdomen stout; first tergite barely three and a half times as long as broad at apex, spiracles very slightly beyond basal third; second much less than twice as long as broad at base, its sides diverging; ovipositor sheath nearly as long as first segment.

Reddish testaceous, abdomen darker, head and thorax (especially along sutures and notauli) tinged with yellow; stemmaticum yellow with a brownish stain between the posterior ocelli; antennae concolorous; prescutum with a narrow median brownish stripe; legs concolorous, front legs anteriorly and all tarsi paler; wings yellowish hyaline, stigma and costa testaceous, veins otherwise dark; sheath reddish fuscous.

Type locality.—Cabin John, Md.

Type.—Cat. No. 41993, U.S.N.M.

One female taken July, 1917, by R. M. Fouts.

Genus HYMENDERLEINIA, new name

Enderleinia CUSHMAN, Proc. U. S. Nat. Mus., vol. 64, Art. 20, 1924, p. 6 (not Schmidt, 1907).

Opheltoideus ENDERLEIN, Stettin. Ent. Ztg., 1912, p. 107 (not Ashmead, 1900).

Genus SESIOPLEX Viereck

This genus was originally based on the single character of the depressed first abdominal segment, by which character it was said to differ from *Campoplex* Gravenhorst (=*Ormogus* Foerster).

In his key to genera of the Campopleginae [2] Viereck ascribed several other characters to the genus, and (p. 177) assigned to it four species besides the genotype. Of these *heliae* (Ashmead) is a *Sagaritis* Holmgren. The other two previously described species, *depressus* Viereck and *validus* (Cresson), will run in Schmiedeknecht's (Opusc. Ichn.) key to *Tranosema* Foerster, failing to stop at (*Omorgus*) = *Campoplex* because of the more or less distinctly broken nervellus. The same character prevents their running to *Eulimneria* Schmiedeknecht.

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[2] Can. Ent., vol. 57, 1925, p. 176.

As I have shown in my description of *Angitia galleriae*[3] the depressed petiole is, in some cases at least, of not even specific significance. The same is true to some extent of the impression of the petiolar area of the propodeum, the fracture of the nervellus, and the depth of the lateral furrows on the petiole. Most of the genera in the Campopleginae are based on such trivial and variable characters as these, and the classification of the group would be much simplified and brought nearer the truth were many of the genera suppressed. It is my opinion that there is no generic difference between *Campoplex*, *Eulimneria*, *Sesioplex*, *Angitia* Holmgren, *Idechthis* Foerster, and *Campoletidea* Viereck, while *Dioctes* Foerster differs only in its lack of the alar areolet. For the time being, however, I shall consider them distinct genera.

This discussion is gone into in order to explain the generic placement of the following new species. It may have been described by Viereck in his "A Preliminary Review of the Campopleginae in the Canadian National Collection," Ottawa; but, because of his use of so many trivial characters in his generic keys, I have found it very difficult to use them, and in the present instance impossible to place the species in any genus satisfactorily.

SESIOPLEX CANADENSIS, new species

Female.—Length, 7.5 mm.; antennae 4 mm.

Head finely coriaceous or shagreened, the face, clypeus, and frons finely, closely punctate; temples somewhat sloping, straight for most of their length, then abruptly turned inward to the occipital carina, the cephalo-caudad length nearly as great as short diameter of eye; diameter of lateral ocellus very nearly as long as ocell-ocular line; eyes slightly emarginate opposite antennae; face very slightly narrower than frons; malar space hardly two-thirds as long as basal width of mandible; clypeus broad, not at all separated medially, its apical margin broadly submucronate medially; antennae stout, flagellum with about 33 joints, those beyond apical third transverse. Thorax short ovate, sculptured like the head but even more opaque, even the speculum entirely opaque; pronotum somewhat rugulose in lower lateral angle; scutellum strongly convex; propodeum very finely rugulose, the petiolar area somewhat impressed; legs moderately stout, hind basitarsus as long as rest combined, inner calcarium reaching slightly beyond middle of basitarsus; areolet narrowly sessile to subpetiolate; recurrent vein beyond middle; nervulus strongly inclivous; postnervulus broken distinctly below middle; exterior angle of second discoidal cell strongly acute; nervellus weakly broken near bottom, somewhat inclivous, discoidella wanting. Abdomen

[3] Proc. U. S. Nat. Mus., vol. 58, 1920, p. 266.

subopaque, stout; petiole distinctly though not strongly depressed, distinctly channelled laterally, the channel posteriorly pitlike; postpetiole broad, depressed; second tergite about as broad at apex as long, gastrocoeli subdistinct, oval; ovipositor sheath hardly twice as long as first segment.

Black; mandibles, palpi, tegulae and legs ferruginous; mandibles more or less black basally; coxae black, front and middle pairs ferruginous below; hind tibia obscurely pale basad of middle above; wings pale infumate, radices yellowish; abdominal venter brownish.

Male.—Essentially like female. The antennae are broken but are evidently nearly as long as body with all joints distinctly longer than thick.

Type locality.—Edmonton, Alberta.

Type.—Cat. No. 42159, U.S.N.M.

Two females and one male from the type locality, May 12–14, George Salt; and three females from St. Agatha, Quebec, May 26, 1929, and one female from Timmins, Ontario, May 15, 1929, the last four collected by the French Ichneumonologist, André Seyrig. One of the paratypes is returned to Mr. Seyrig for deposit in the Museum National d'Histoire Naturelle, Paris, and another is deposited in the Canadian National Collection, Ottawa, Ontario.

PRISTOMERUS BAUMHOFERI, new species

Closely related to *agilis* (Cresson) but at once distinguishable in the female by its pale yellow frontal orbits and apical margins of tergites 3 to 7; and in the male by the parallel eyes and smaller ocelli.

Female.—Length 5–6.5 mm. (type 5.5 mm.).

Head transversely oval; eyes parallel; face medially elevated, sparsely punctate; clypeus strongly convex, apically truncate, suture straight; malar space hardly two-thirds basal width of mandible; temples narrow, strongly convexly receding; diameter of ocellus and ocell-ocular line equal; antennae a little more than half as long as body. Thorax less than twice as long as deep, finely punctate; prothorax subpolished, rugulose in impression; notauli deep but broadly impressed anteriorly, obsolete posteriorly; scutellum strongly convex; propodeum finely rugulose-punctate, areolet pentagonal, twice as long as broad, much shorter than petiolar area; radius weakly curved at apex, postnervulus broken slightly above middle; legs rather slender, femoral tooth at about apical third, small to obsolete. Abdomen rather slender, postpetiole and second tergite finely longitudinally aciculate; other tergites finely shagreened, the second somewhat longitudinally so basally; second a little more than three times as long as broad at base; ovipositor sheath slightly longer than combined first and second tergites.

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General color ferruginous; occiput and stemmaticum brown; face, mouth parts, malar space, and anterior orbits yellow, the face somewhat stained with reddish; scape and pedical pale in front, flagellum black; notauli and scutellum paler than surrounding areas, lateral portions of postscutellum and base of propodeum brown; anterior margin of pronotum, tegulae and radices whitish; wings hyaline, venation dark brown, stigma broadly pale along costal margin; front and middle coxae, trochanters and tarsi and apices of their femora stramineous, these legs otherwise pale testaceous; hind legs testaceous, basal joint of trochanter piceous, apex of femur stramineous, tibia and tarsus fuscous, the tibia indefinitely paler in middle; second tergite somewhat piceous especially toward base, tergites 3 to 7, pale yellowish at apex.

Male.—Essentially like female but with both pale and dark markings more extensive; face and pronotum entirely yellow; prescutum anteriorly and lateral lobes in middle brown; front and middle tibiae and hind coxae apically and below stramineous; hind femur reddish piceous, pale at base and apex; abdomen with all tergites piceous with apical margins whitish.

Host.—*Rhyacionia frustrana* var. *bushnelli* Busck.

Type locality.—Halsey, Nebraska.

Type.—Cat. No. 41994, U.S.N.M.

Five females and one male reared from the host by L. G. Baumhofer, under Hopkins U. S. No. 17508.

CREMASTUS GRACILIPES Cushman

Three rearings of this species from the type-host (*Dicymolomia julianalis* Walker) have added three females and five males (the latter sex undescribed) to the national collection. These are as follows: 1 of each sex reared by E. Daecke at Rockville, Pa., on June 22, 1915; 1 female and 4 males reared September 22, 1909, at Collins, Pa.; and 1 female reared March 14, 1924, at Smith's Point, Tex. There is also an apparently indistinguishable female reared from the Oriental Peach Moth (*Laspeyresia molesta* Busck) at New Brunswick, N. J., by Alvah Petersen.

The females show a variation in color from that of the type and a phase in which the red color of the head is replaced by yellow and the thorax and abdomen are much more extensively black.

The male shows the same sort of variation in color with frequently the entire lateral face of pronotum, the notauli and more or less of the mesopleurum yellow; also the legs are paler, especially basally.

In my key the male runs to couplet 3, where it agrees with neither alternate entirely. The diameter of the lateral ocellus is about equal

to the ocell-ocular line and the malar space is very slightly shorter than basal width of mandible.

In both sexes the stigma is broadly pale along its anterior margin.

CREMASTUS CARPOCAPSAE, new species

Very closely related to *C. gracilipes* Cushman, from which the female is distinguished with difficulty, though the male is quite obviously distinct.

Female.—Differs from *gracilipes* apparently only in the uniformly brown stigma; the slightly broader abdomen, the second tergite being hardly four times as long as broad at base; the slightly larger ocelli, the diameter of which is fully as long as the ocell-ocular line; and the shorter malar space, which is only about two-thirds as long as the basal width of mandible.

Color varying as in *gracilipes* as described above with hind femora in the dark form somewhat infuscate.

Male.—Runs to couplet 3 in my key[4] as does *gracilipes* male. From *gracilipes* it differs principally by having the malar space hardly two-thirds as long as the basal width of mandible, the diameter of a lateral ocellus much longer than ocell-ocular line, the abdomen broader, the stigma uniformly colored, and the hind legs infuscate.

Host.—*Carpocapsa pomonella* (Linnaeus).

Type locality.—Lawrence County, Ohio.

Type.—Cat. No. 41995, U.S.N.M.

Seven females and two males in rather poor condition received from L. A. Stearns and reared by him August 4 to September 9, 1927.

CREMASTUS (ZALEPTOPYGUS) HARTII Ashmead (new combination)

Through the kindness of Dr. T. H. Frison, of the Illinois State Natural History Survey, in bringing them to Washington I have been able to examine the types of this species. Both sexes run in my key to *tetralophae* Cushman, but differ as follows:

Female.—Length 6 mm., antennae 4 mm., ovipositor sheath 2 mm.

Eyes barely as long as width of face, very slightly divergent below; malar space subequal to basal width of mandible; foveo-ocular line distinctly more than half as long as interfoveal line; diameter of ocellus much shorter than ocell-ocular line; thorax more slender, propodeum longer and less steeply sloping; pronotum laterally shagreened but not punctate; mesoscutum less distinctly punctate, notauli shallow; scutellar carinae obsolete except at base; mesopleurum not striate above, punctation very fine; radius only slightly

[4] Proc. U. S. Nat. Mus., vol. 53, 1917, p. 511.

beyond middle of stigma; nervellus nearly perpendicular, slightly broken not far below middle; hind basitarsus hardly three-fifths as long as tibia and distinctly shorter than rest of joints combined; postpetiole barely thicker than petiole; second tergite two and a half times as long as broad at base, sides divergent.

Pale yellowish testaceous; occiput, vertex, and frons fuscous; orbits yellow; antennae fuscous with apices of joints of basal half narrowly pale; stigma largely whitish, other veins brown; legs somewhat infuscate; prescutum entirely and areas between scutellum and wing bases fuscous, as are also basal half of second tergite and more or less of sixth and seventh.

Male.—Eyes divergent below; diameter of ocellus distinctly shorter than ocell-ocular line; second tergite little more than twice as long as broad at base; color like female.

CREMASTUS RHYACIONIAE, new species

Very similar to *epagoges* Cushman, to which species the female runs in my key to North American species. Because of its large eyes and ocelli the male runs to *forbesii* Weed.

Female.—6–7.5 mm. (type 7 mm.).

Differs from *epagoges* female principally as follows: Face distinctly narrower than height of eye; malar space shorter than basal width of mandible; pronotum laterally polished, very weakly foveolate at bottom of impression (in *epagoges* the pronotum is shagreened laterally and strongly foveolate in impression); mesoscutum more finely and sparsely punctate, notauli weaker; ovipositor sheath a little more than twice as long as first tergite.

Face black medially; orbits uninterrupted yellow but much narrower than in *epagoges*, especially at top of eye; thorax entirely black except humeral angle of pronotum which is brownish and basal part of scutellar carinae which is whitish (sometimes the scutellum is more or less reddish brown); stigma broadly pale along anterior margin.

Male.—Differs from *epagoges* male as follows: Eyes much longer than width of face; malar space hardly half as long as basal width of mandible; diameter of ocelli more than half as long as postocellar line and nearly twice ocell-ocular line.

Host.—*Rhyacionia frustrana* var. *bushnelli* Busck.

Type locality.—Pactola, S. Dak.

Type.—Cat. No. 41997, U.S.N.M.

Seven females and two males reared by L. G. Baumhofer from the host in *Pinus ponderosa* under Hopkins U. S. No. 17511.

CREMASTUS PTEROPHORI, new species

Like *rhyacioniae* this species runs in my key to *epagoges* Cushman in the female and to *forbesii* Weed in the male. In size of ocelli the female agrees better with *forbesii.*

Female.—Length 10 mm.; antennae 7 mm.; ovipositor sheath 3.5 mm.

Head in frontal view very strongly transverse, eyes bulging and faintly, broadly emarginate within; face nearly as broad as height of eye, opaque, shagreened, and rather densely punctate, medially somewhat elevated, the elevation continuing on to clypeus, which is rather prominent, inflexed and strongly rounded at apex, shining and more sparsely punctate than face; malar space as long as basal width of mandible; temples very strongly receding, nearly flat; diameter of ocellus subequal to ocell-ocular line and two-thirds postocellar line. Thorax opaque shagreened and punctate, the punctures dense on mesoscutum, more sparse elsewhere; pronotum laterally and speculum subpolished; notauli well defined and foveolate, prescutum prominent; scutellum punctate opaque, laterally margined; propodeum subopaque, shagreened, and punctate, apically more or less transversely rugulose, combined areola and petiolar area of almost uniform width, the areola nearly as long as petiolar area; propodeal "neck" in dorsal view shallowly concave laterally, extending well beyond middle of coxae; cubitus and discoideus distinct beyond recurrent; nervellus obsoletely broken below middle. Abdomen slender; first segment barely longer than dorsal length of propodeum, dorsolateral carinae present before spiracles, postpetiole abruptly enlarged; second tergite about four times as long as broad at base, apaque striato-shagreened; tergites 3 to 6, opaque, shagreened, and punctate, third definitely less deep than fourth.

Black with thorax laterally and abdomen more or less obscure red. Head black with orbits completely, malar space, sides of clypeus and mandibles yellow, as is also the under side of scape and pedicel; antennae otherwise black with apices of flagellar joints more or less distinctly paler; ventral margin of pronotum, lateral margins of mesoscutum, scutellum, a streak on mesopleurum, metapleurum more or less, and all lateral sutures of thorax reddish, the mesoscutal and scutellar markings inclining to yellow; front and middle legs testaceous, their coxae and trochanters stramineous; hind leg largely blackish, the coxa at apex, trochanter, femur apically and tibia in middle pale; abdomen black and piceous red in the usual arrangement, the plica pale.

Male.—Eyes larger, face much narrower than height of eye, malar space about half basal width of mandible, diameter of ocellus as

long as postocellar line and nearly four times as long as ocell-ocular line. Face entirely and all thoracic markings yellow, the latter including the lateral aspect of the pronotum, the notauli and a median spot on mesoscutum; petiole laterally and lower edge of compressed portion of abdomen pale. In one of the males the thorax laterally and the abdomen are largely pale red, while the hind leg is black only on apex of tibia and tarsi.

Host.—Oidaematophorus kellicottii Fish.

Type locality.—Dane County, Wis.

Type.—Cat. No. 41996, U.S.N.M.

Two females and five males reared by F. P. Breakey during May and June, 1928.

Genus CREMASTUS Gravenhorst (=CREMASTIDEA Viereck) (new synonymy)

Cremastidea is said to differ from *Cremastus* Gravenhorst by the very short malar space and by the fact that the propodeum overlies the hind coxae to their middle.

The first character is subject to great variation in *Cremastus* and is sometimes a sexual difference; while the second is characteristic of typical *Cremastus.*

The genotype, *Cremastidea chinensis* Viereck, is a typical *Cremastus.*

(CREMASTIDEA CREMASTUS CHINENSIS (Viereck) (new combination)

In addition to the types the National Museum Collection contains six specimens reared by D. T. Fullaway at Kobe, Japan, as parasites of the rice borer, *Chilo simplex* Butler.

THERSILOCHUS PROVANCHERI Ashmead (=THERSILOCHUS PROVANCHERI Cushman)

In renaming Provancher's preoccupied *pallipes* I overlooked the fact that Ashmead had already done so.[5] Dalla Torre catalogued the Ashmead reference under *Porizon angularis* (Provancher).

ALLOPHRYS OCULATUS (Ashmead) (new combination)

Thersilochus oculatus Ashmead, Proc. Zool. Soc. London, 1895, p. 779, male.
Insurgus nigriceps Ashmead, Trans. Ent. Soc. London, 1900. p. 273, female. (New synonymy.)

The large, dorsally convergent eyes of *Allophrys* Foerster constitute a male secondary sexual character, the eyes of the female being of normal size and parallel within.

The association of the sexes is based on a series of specimens collected on the windward side of Grenada, West Indies, by H. H. Smith.

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[5] Bull. 1, Colo. Biol. Assn. 1890, p. 24.

Family BRACONIDAE

BRACHISTES MAGDALI (Cresson)

Calyptus magdali Cresson, Psyche, vol. 2, 1878, p. 189.
Brachistes magdali Brues, Bull. Wisc. Nat. Hist. Soc., vol. 8, 1910, p. 50. (New synonymy.)

Both Cresson's and Brues's types are from Massachusetts and both were reared from the same host, *Magdalis olyra* Herbst.

BRACHISTES STRIGITERGUM, new species

Of the same form as *B. magdali* (Cresson) but at once distinguishable by the strongly striate second tergite.

Female.—Length, 5.5 mm.; antennae, 5 mm.

Temples broad but distinctly narrower than eyes, which are distinctly bulging, especially behind; vertex and temples moderately densely and very finely punctate; face more coarsely and more densely so; clypeus coarsely confluently punctate; eyes shorter than in *magdali*, being only about a third longer than broad and little more than twice as long as malar space; basal two joints of flagellum equal in length and fully four times as long as thick at apex. Thorax polished laterally and ventrally, subpolished and densely pilose dorsally; pronotal groove, notauli, prepectal furrow and mesepisternal furrow foveolate; metapleurum rugose; propodeum coarsely rugose with a median carina basally and parallel carinae at apex, posterior angles prominent. Abdoment barely longer than thorax, the apical segments strongly retracted; first tergite broader than long, striate, with prominent dorsal carinae, between which the surface basally is deeply concave; second tergite longitudinally striate throughout, the striae not converging behind; other tergites smooth and polished, second suture not foveolate; sheath about as long as abdomen.

Black; palpi and legs testaceous; all tarsi and hind tibia brownish; antennae black, piceous at base, wings very dilutely infumate.

Type locality.—Duncan, B. C.

Type.—Cat. No. 41998, U.S.N.M.

Paratypes.—Two are deposited in the Canadian national collection.

Four females reared June 8, July 13 and 20, 1928, by W. G. Mathers from a fir tree, under his number 17241, lots 1, 11, and 13.

MICROBRACON LENDICIVORUS, new species

Because of the deep foveolate tergal sutures and transverse furrows of the tergites it runs in Ashmead's[6] generic key to 4, but differs from the only genus falling there, *Glyptomorpha* Holmgren, in its

[6] Proc. U. S. Nat. Mus., vol. 23, 1900, p. 137.

lack of oblique grooves on tergites 2 to 4. Following the second alternate of the first couplet it runs, because of the median carina of the propodeum, to *Tropidobracon* Ashmead (p. 139) and agrees fairly well with all the characters assigned to that genus. From apparently all species hitherto assigned to *Microbracon* it differs by the abdominal sculpture.

Female.—Length 4 mm.

Head strongly transverse, the temples sharply convexly sloping; eyes bulging, nearly hemispherical; face fully a half wider than length of eye; malar space a half longer than basal width of mandible and subequal to width of mouth opening; antennae as long as body, slender, tapering from before middle; first joint of flagellum nearly three times as long as thick and very slightly longer than second, all other joints much longer than thick, those near apex fully twice as long as thick. Thorax short ovate, smooth and polished; notauli distinct; scutellum flat, fovea foveolate; propodeum with a median carina, high at apex, but not reaching base; radius far before middle of stigma; alar areolet rather short, first intercubitus and second abscissa of radius about equal in length; hind tarsus slightly shorter than tibia, basal joint as long as rest combined, third and fifth equal. Abdomen broad with a median ridge on tergites 2 to 6, originating in a triangular embossed area at base of second and becoming weaker toward apex, each of these tergites except second with a subapical, transverse, more or less distinctly foveolate furrow, sutures foveolate, second and third longitudinally rugose, third with oblique foveolate grooves basally; fourth to sixth opaque punctate; triangular area of first tergite elevated subapically, coarsely rugose behind elevation, smooth before; tergites beyond sixth much less heavily chitinized; ovipositor about a fourth longer than body, slender.

Head and thorax testaceous; antennae blackish, scape and pedicel reddish; wings hyaline, venation brown, tegulae stramineous; front and middle legs stramineous, apices of tarsi blackish; hind leg testaceous, coxa somewhat piceous above; tibia fuscous toward apex, apical joint of tarsus black; abdomen piceous basally, yellowish white apically; first tergite testaceous basally, very narrowly whitish at apex; second and third tergites laterally and the third apically whitish; tergites 4 to 6 narrowly piceous basally; sheath stramineous, blackish at base and apex, pubescence black.

Male.—Median ridge of abdomen very faint; only first five tergites heavily chitinized and sculptured, the sixth smooth polished and without subapical groove; tergites 4 and 5 longitudinally striate but more finely so than 2 and 3; white color confined to narrow apical and lateral bands on tergites 2 to 5.

Type locality.—Los Banos, Luzon, Philippine Islands.

Host.—Midge maggots on *Ficus nota* Blanco.

Type.—Cat. No. 41999, U.S.N.M.

Described from one female and four males reared January 12–15, 1921, by F. X. Williams.

MICROBRACON UICHANCOI, new species

Closely related to *lendicivorus* Cushman, from the foregoing description of which it differs as follows: Smaller; width of face less than one and a half times as long as diameter of eye; malar space subequal to basal width of mandible and much shorter than width of mouth opening; antennae filiform, not tapering from before middle, subapical joints distinctly less than twice as long as thick; basal joint of hind tarsus not so long as rest combined, third distinctly longer than fifth; median ridge of abdomen fading out on fourth tergite; second tergite irregularly rugose, others opaque punctate. Head and thorax paler; stigma stramineous; hind coxa entirely pale testaceous; abdomen nearly uniform pale testaceous, apices of tergites only slightly paler, suturiform articulation and sometimes a stain on each side of middle of second tergite blackish; sheath only slightly paler in middle.

Male.—Except sexually like female with abdominal sculpture less well defined.

Type locality.—Los Banos, Luzon, Philippine Islands.

Type.—Cat. No. 42000, U.S.N.M.

Three females and two males apparently reared by L. B. Uichanco, the females under Accession No. 18343, College of Agriculture, University of the Philippines, and the males from Mount Maquiling, Luzon, under Accession No. 18152.

Family AULACIDAE

PYCNAULACUS, new genus

Running this genus in Kieffer's key to genera [7] I am somewhat uncertain as to which alternate of the first couplet to follow because of the presence of a trace of the second intercubitus on the radius. Considering the wing to have three cubital cells it runs to couplet 4, where it agrees with the first alternate in the apically open second cubital cell, but disagrees in its possession of discal veins in the hind wing. Under couplet 5 it agrees with both characters attributed to *Micraulacinus* Kieffer. Following the lead of the second alternate of couplet 1 it agrees with neither alternate of couplet 9 because the

[7] Das Tierreich, Lief. 30, 1912, p. 344.

claws are entirely toothless. Of the genera beyond this point it agrees best with *Odontaulacus* Kieffer, from which it differs, in addition to its lack of claw teeth, in its short ovipositor and the lack of ovipositor guides on the hind coxae.

Frons convex, without scrobes or carinae; occipital carina effaced; eyes bare; pronotum with anterior margins rounded; prescutum with a shallow median fovea anteriorly, the lobes rounded; propodeum strongly elevated; stigma very broad with radius beyond middle; second intercubitus represented by a very short stub on radius; third intercubitus very largely hyaline; first recurrent about two-thirds its length before first intercubitus; first brachial cell as broad as long; hind wing with mediella, basella, cubitella, and nervellus somewhat developed, nervellus slightly antefurcal; hind coxae in female without ovipositor guides; claws without teeth; abdomen in female little longer than thorax, broadly truncate at apex; ovipositor sheath barely as long as abdomen.

Genotype.—*Pycnaulacus brevicaudus*, new species.

PYCNAULACUS BREVICAUDUS, new species

Female.—Length, 6 mm.; antennae, 4 mm.; ovipositor sheath, 2.5 mm.

Head smooth; malar space and sides of face very densely and finely punctate opaque; frons more sparsely and less finely punctate; first and third joints of flagellum subequal in length and about two-thirds as long as second joint, others gradually shorter, penultimate joint twice as long as thick; transverse rugae of prescutum very coarse, those of scutellum fine, lateral lobes of mesoscutum with only one prominent carina, this at about the middle with much finer rugosity before and behind; thorax laterally confused rugose, with the impressions of pronotum and mesopleurum shining and more distinctly rugose, upper division of metapleurum polished; propodeum concentrically rugose before, reticulately rugose behind, insertion of abdomen.

Head and thorax black; antennae black with scape pale testaceous and pedicel brown; mandibles dark piceous; legs beyond coxae testaceous; wings yellowish hyaline, immaculate; tegulae brownish testaceous; abdomen ferruginous more or less darkened toward apex, extreme base of petiole black.

Type locality.—Palo Alto, Calif.

Type.—Cat. No. 42160, U.S.N.M.

One specimen captured May 14, 1922, by E. O. Essig.

U. S. GOVERNMENT PRINTING OFFICE: 1929

A NEARLY COMPLETE CARAPACE OF A FOSSIL TURTLE, AMYDA VIRGINIANA (CLARK)

By W. Gardner Lynn
Of the Johns Hopkins University

The species *Amyda virginiana* was first described under the name *Trionyx virginianus* by Dr. William Bullock Clark in 1895 from fragments found at Aquia Creek, Va., in Eocene deposits of the Aquia Creek stage. On a recent trip to this same locality a nearly complete carapace referable to this species was obtained; and since this is, so far as can be ascertained, the most complete specimen of this large fossil turtle yet discovered it seems worthy of description.

The type fragments of the species were described by Clark as follows:

> Fragments of costals with tuberculated surfaces characteristic of the genus *Trionyx*. The longitudinal ridges are prominent, at times irregular and inosculate; relatively remote and separated by intervals about twice their width, generally entirely disappear near the margins of the plates.
>
> A number of fragments of the plates of this large species were found in the vicinity of Aquia Creek, Va. This species shows some points of similarity with *T. cariosus* (Cope), from the Eocene of New Mexico, but is undoubtedly a different form.
>
> *Dimensions.*—Length of largest fragment, 130mm.; width, 45mm.; thickness, 18mm.

Hay, in his Fossil Turtles of North America, gives more detailed descriptions and measurements of the 2-type fragments which, he believes, indicate a possibility that the two represent distinct species. This idea is based upon the fact that the sculpturing of the two fragments differs. The first fragment (the distal portion of a costal) (pl. 2, center) shows rather regular sculpturing, which consists of ridges and grooves, five of which are found in a line 22 mm. long. The sculpturing of the second fragment (the proximal portion of a costal) (pl. 2, lower) is more irregular and the pits are somewhat larger, five being contained in a line 25 mm. long. Moreover, Hay notes resemblances to *Amyda pennata* (Cope) of the Eocene of New Jersey, although he does not seem to believe that the two are synonymous. However, it is clear that the position and even the authenticity of this little-known species is much in question, and it is

believed that the information obtained from the specimen here described will be of advantage in clearing up these points.

The present specimen (Cat. No. 11944, U.S.N.M.) consists of a carapace which is complete, except for the distal portions of the fourth, fifth, sixth, and seventh costals of the left side and small portions of the neurals. The carapace is broad, rounded in front, and somewhat truncate behind. At the free margins of the costals the upper layers of bone project somewhat beyond the lower layers, causing a longitudinal grooving of the carapace; beyond this the margins drop off gently to a thin edge. This was an exceedingly large turtle; the length of the carapace measured in a straight line is 735 mm., its greatest width 640 mm., not including the extension of the ribs beyond the margin of the shell. It is composed of a nuchal plate, 7 neurals, and 8 pairs of costals, the 2 posterior pairs meeting in the mid line.

The nuchal measures 380 mm. across and 87 mm. in an anteroposterior direction in the mid line, narrowing toward the outer ends. It is 27 mm. thick in the central portions and tapers off to a thin edge at the margins. Little ornamentation is apparent on this bone.

The measurements of the costals of the right side (where all are complete) are given in the following table:

Costal No.	Length	Width at center	Greatest thickness	Least thickness
	Mm.	*Mm.*	*Mm.*	*Mm.*
1	256	104	24	9
2	272	98	19	11
3	298	80	21	10
4	285	82	18	11
5	273	89	17	12
6	223	97	17	10
7	186	60	15	11
8	95	67	14	12

The ribs project beyond the margins of the carapace for some distance; the best preserved one, that of the second costal of the left side, extends out 92 mm. The lengths in the above table are taken only to the border of the costal, not out onto the projecting rib. Decided ridges are produced on the under sides of the costals by the ribs, which are in most cases nearer the anterior borders of the costals than the posterior borders. These ridges are plainly seen on Plate 1, left, which gives a ventral view of the entire specimen.

The sculpture corresponds closely with Hay's description for the type fragments. It consists of ridges and grooves running at right

angles to the sutures, the grooves sometimes broken up into pits by cross-ridges. In the best-preserved portions of the carapace this sculpturing is continued quite to the beveled margin of the shell. The width of ridges and grooves is variable, being in general greater toward the posterior end. Thus on the first costal plate five ridges and five grooves are contained in a line 18 mm. long; on the fourth costal the same number is contained in a line 22 mm. long; and on the eighth costal a line 28 mm. long is required. Moreover, the ridges run more irregularly and are more broken up on the anterior costals than on the posterior ones; and in all the costals the sculpturing is in general much more regular toward the distal ends. Plate 2, upper, shows the sculpturing on a large fragment from the distal end of the fifth costal of the right side. The ridges and pits on the neurals are extremely irregular in arrangement, producing a reticulate appearance. These facts indicate that the type fragments do belong to a single species, the difference in sculpturing described by Hay being attributable to the differences normally present between distal and proximal portions of the plates.

Moreover, little doubt remains as to the authenticity of the species. Hay's description of *Amyda* (*Trionyx*) *cariosa* (Cope) shows that it differs considerably not only in length and thickness but also in the sculpturing, for in *Amyda cariosa* the ornamentation consists chiefly of irregularly arranged pits, whereas in *Amyda virginianus* long longitudinal grooves predominate. The chief difference between *Amyda* (*Trionyx*) *pennata* (Cope) and the specimen under consideration is, as Hay remarks, that in the former the pits "are arranged in rows that run from the sutural edges toward the middle of the bone and at the same time toward the distal end." This is quite different from the condition in *Amyda virginianus*, where the ridges show no tendency to run toward the distal ends of the bone. Moreover, the fragments of *Amyda pennata* indicate that it was a much smaller turtle than was the one represented by the present specimen. However, the known fragments of *Amyda pennata* are so small and so few that it is impossible to clear up this point with absolute finality, although evidence thus far available seems to indicate that this species also is distinct from *Amyda virginianus*.

BIBLIOGRAPHY

CLARK, WILLIAM B.

Johns Hopkins University Circular, vol. 15, No. 4, p. 4, 1895.

U. S. Geol. Survey Bull. 141, p. 59, pl. 8, figs. 1*a* and 1*b*, 1896.

HAY, OLIVER P.

U. S. Geol. Survey Bull. 179, p. 455, 1902.

Fossil Turtles of North America, p. 515, pl. 96, figs. 7 and 8, text figures, 670 and 671, 1908.

EXPLANATION OF PLATES

Plate 1

Left: Ventral view of the carapace described above, × ⅛.
Right: Dorsal view, × ⅛. A foot rule is shown at the side.

Plate 2

Upper: A fragment forming the distal end of the fifth costal of the right side to show the sculpturing, × ½.
Center: One of the type specimens. Distal portion of a costal plate, × 1. Museum Wagner Free Institute of Science, Philadelphia.
Lower: Type specimen. Proximal portion of a costal plate, × 1. Wagner Free Institute of Science, Philadelphia.

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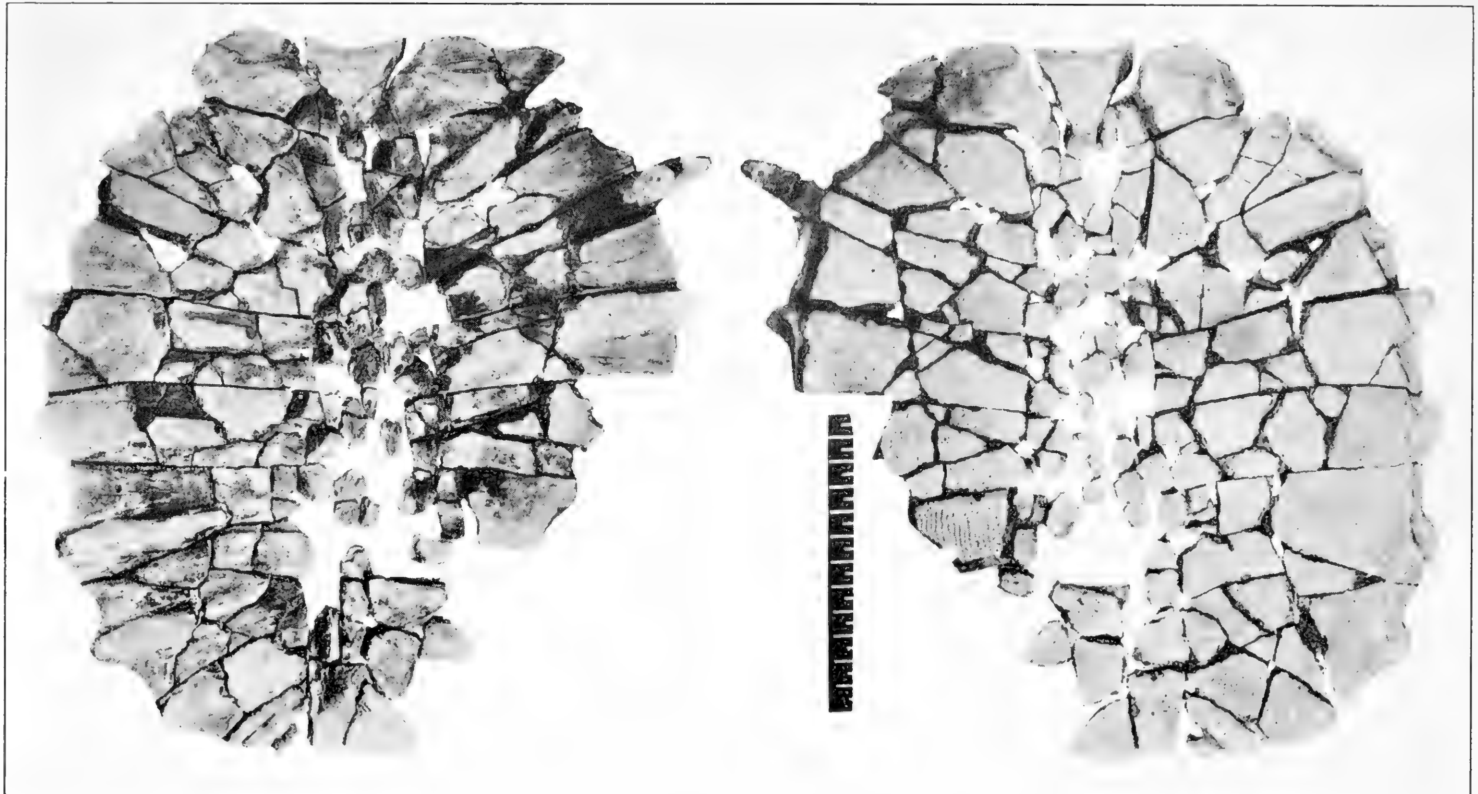
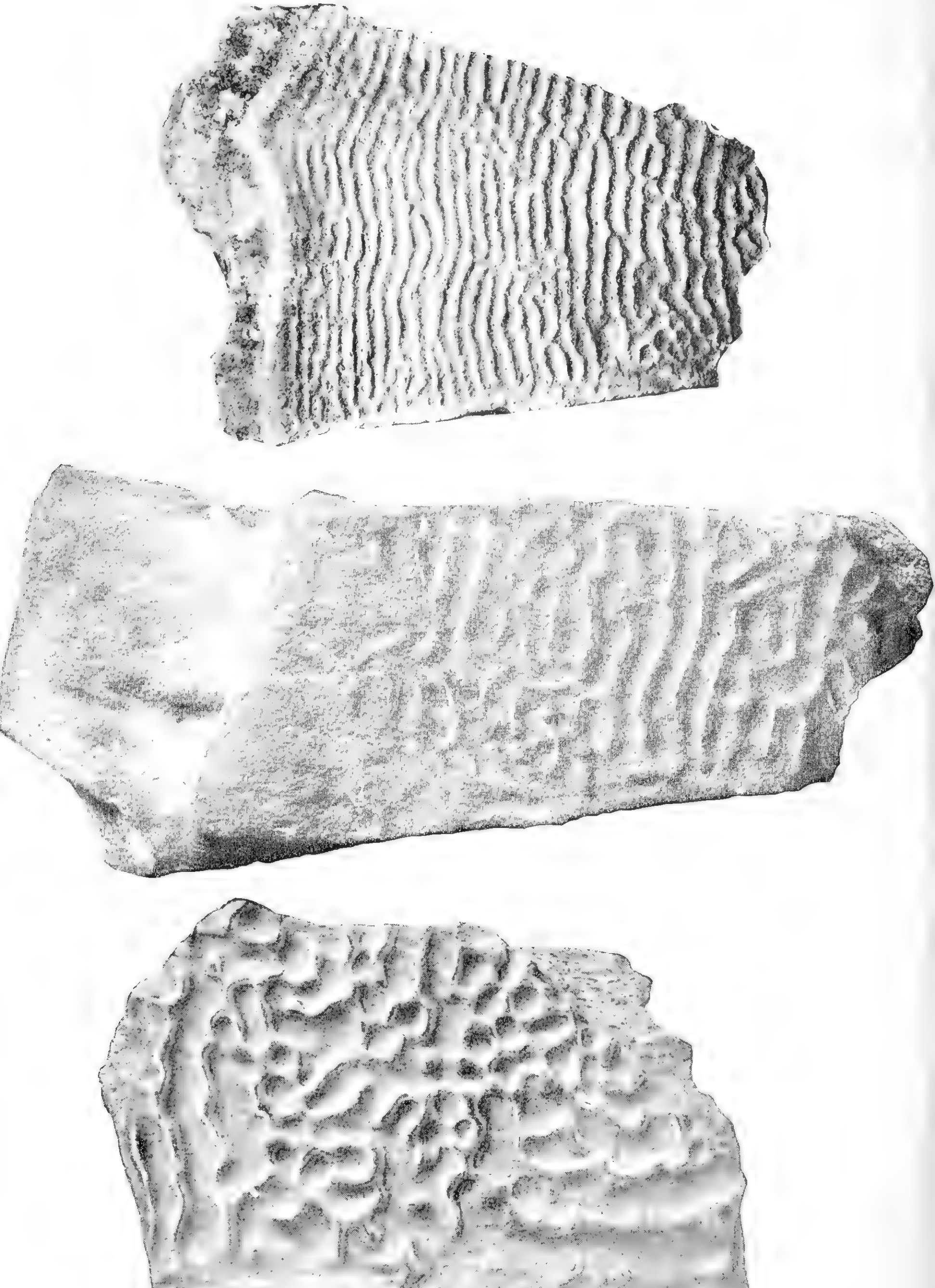


Nearly Complete Carapace of Amyda virginiana (Clark)

For explanation of plate see page 4



FRAGMENTS OF COSTAL PLATE OF AMYDA VIRGINIANA (CLARK)

FOR EXPLANATION OF PLATE SEE PAGE 4